

West Coast Estuarine Managed Fishery (Area 2: Peel-Harvey Estuary) & Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery

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

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Overview

This report provides a comprehensive description of the West Coast Estuarine Managed Fishery (WCEMF) Area 2 (Peel-Harvey Estuary) and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery in Western Australia and contains information relevant to assist with the assessment of these fisheries against the Marine Stewardship Council (MSC) standard (v1.3) for sustainable fishing. The WCEMF Area 2 uses haul and gillnets to target predominantly sea mullet (*Mugil cephalus*), and crab traps to target blue swimmer crabs (*Portunus armatus*), whilst recreational crab fishers in the Peel-Harvey Estuary primarily use drop and scoop nets for catching blue swimmer crabs.

The first part of this document (Sections 1 – 5) provides an overview of these fisheries and the aquatic environment in which they operate, including information about the biology of the target species, development of the fishery, fishing methods and gear used, the management system in place, and external factors that may influence fishery operations and / or target species populations. The remainder of document provides more detailed information for assessing the fishery against the performance indicators under MSC Principles 1, 2 and 3.

MSC Principle 1 (Sections 6 – 8) provides information to assess the status of the target species' stocks. These sections provide information on the current stock status of sea mullet and blue swimmer crabs and includes a description of the stock assessment approach and harvest strategies employed for ensuring the sustainability of these stocks.

MSC Principle 2 (Sections 9 – 11) relates to the impact of the fishery on the marine environment in which it operates. These sections include, or point to, all currently available information on the catch of retained non-target species, bycatch, interactions with endangered, threatened and protected (ETP) species, as well as a description of the habitats and ecosystem within Peel-Harvey Estuary and fishery-related impacts on habitat and ecosystem structure and function. Where detailed quantitative data are not available, a risk assessment approach has been used to assess the level of risk associated with any identified fishery-specific issues. The issues identified and their associated risk ratings are provided throughout the Principle 2 sections, where relevant.

MSC Principle 3 (Sections 12 – 13) provides information to assess the governance and management in place for the fishery. Governance information provided includes an overview of the local, national and international legal frameworks relevant to the management of the fishery, a description of the roles, responsibilities and consultation processes undertaken with fishery stakeholders, the long-term objectives and the incentives in place for sustainable fishing. These sections also include information on the fishery-specific management system, including fishery-specific objectives, the decision-making process, compliance and enforcement, ongoing research and an evaluation of the performance of this management system in recent years.

Although this document has been divided into MSC Principle-specific sections, it should be considered in its entirety as many sections provide supporting and complementary information. While this document is intended to provide a comprehensive account of these

fisheries, it is by no means meant to be the only source of information for assessing the fisheries. If there is uncertainty regarding any parts of the descriptions and information herein, stakeholders should contact the Department so that any such issues can be addressed in subsequent updates of this document. This document should also be read in conjunction with the *Finfish Resources of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020* and the *Blue Swimmer Crab Resource of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020*.

Table of Contents

1. Aquatic Environment	1
2. Target Species / Stock Description	3
2.1 Sea Mullet.....	3
2.1.1 Taxonomy and Distribution.....	3
2.1.2 Stock Structure	3
2.1.3 Life History	3
2.2 Blue Swimmer Crab	6
2.2.1 Taxonomy and Distribution.....	6
2.2.2 Stock Structure	6
2.2.3 Life History	7
3. Fishery Information.....	11
3.1 Commercial Fishing Activities.....	11
3.1.1 Development of the Commercial Fishery.....	11
3.1.2 Current Commercial Fishing Activities.....	11
3.1.3 Fishing Gear and Methods.....	14
3.1.4 Commercial Catch and Effort.....	19
3.2 Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery.....	24
3.2.1 Current Recreational Fishing Activities	24
3.2.2 Fishing Gear and Methods.....	24
3.2.3 Blue Swimmer Crab Recreational Catch and Effort	27
4. Fishery Management	29
4.1 Commercial Management System.....	29
4.1.1 FRMA.....	29
4.1.2 FRMR	29
4.1.3 Management Plan	30
4.1.4 Notices and Orders	31
4.2 Recreational Management System	31
4.2.1 FRMA.....	31
4.2.2 FRMR.....	32
4.2.3 Notices and Orders	32
4.3 Harvest Strategies	32
4.4 Integrated Fisheries Management (IFM).....	33

4.5 Environmental Management under the Ramsar Convention.....	33
4.5.1 Monitoring Programs.....	34
5. External Influences	35
5.1 Catch from Other Fisheries	35
5.1.1 Sea Mullet.....	35
5.1.2 Blue Swimmer Crabs.....	36
5.2 Market Influences	36
5.3 Environmental Influences.....	36
5.3.1 Eutrophication	36
5.3.2 Climate Change	39
5.3.3 Introduced Pests.....	40
5.4 Urban and Other Developments	40
5.4.1 Point Grey Development	41
MSC Principle 1.....	43
6. Stock Status	43
6.1 Current Stock Status	43
6.1.1 Sea Mullet.....	43
6.1.2 Blue Swimmer Crab	45
7. Stock Assessment	48
7.1 Assessment Description.....	48
7.1.1 Overview	48
7.1.2 Sea Mullet.....	49
7.1.3 Blue Swimmer Crab	53
7.2 Appropriateness of Assessment.....	59
7.3 Assessment Approach	59
7.4 Uncertainty in the Assessment	60
7.5 Evaluation of Assessment.....	60
7.6 Peer Review of Assessment.....	61
8. Harvest Strategy	62
8.1 Framework.....	62
8.1.1 Design.....	62
8.1.2 Evaluation.....	63
8.1.3 Monitoring.....	63

8.1.4 Review	63
8.2 Reference Points	64
8.2.1 Appropriateness of Reference Points	64
8.2.2 Level of Target Reference Points	64
8.2.3 Level of Threshold Reference Points	64
8.2.4 Level of Limit Reference Points.....	65
8.3 Control Rules and Tools	65
8.3.1 Design and Application	65
8.3.2 Accounting for Uncertainty	67
8.3.3 Evaluation.....	67
8.4 Information and Monitoring	68
8.4.1 Range of Information	68
8.4.2 Monitoring.....	70
MSC Principle 2	78
9. Fishery Impacts	79
9.1 Risk Assessments	79
9.1.1 Environmental Management System.....	79
9.1.2 Productivity Susceptibility Analysis (PSA)	79
9.1.3 Scale Intensity Consequence Analysis (SICA) and Consequence Spatial Analysis (CSA).....	79
9.2 Retained (Non-Target) Species	80
9.2.1 Commercial Net Fishery.....	80
9.2.2 Commercial Trap Fishery.....	87
9.2.3 Recreational Drop Net Fishery	88
9.2.4 Recreational Scoop Net Fishery	91
9.3 Bycatch	92
9.3.1 Commercial Net Fishery.....	92
9.3.2 Commercial Trap Fishery.....	94
9.3.3 Recreational Drop Net Fishery	95
9.3.4 Recreational Scoop Net Fishery	95
9.4 ETP Species.....	96
9.4.1 Commercial Net Fishery.....	97
9.4.2 Commercial Trap Fishery.....	97
9.4.3 Recreational Drop Net and Scoop Net Fisheries	97

9.5 Habitats	98
9.5.1 Commercial Net Fishery	104
9.5.2 Commercial Trap Fishery	105
9.5.3 Recreational Drop Net Fishery	106
9.5.4 Recreational Scoop Net Fishery	108
9.6 Ecosystem	109
9.6.1 Commercial and Recreational Fisheries	111
10. Managing Ecological Impacts	112
10.1 Commercial Net and Trap Fisheries	112
10.2 Recreational Drop and Scoop Net Fisheries	114
11. Information and Monitoring	116
11.1 Commercial Net and Trap Fisheries	116
11.2 Recreational Drop and Scoop Net Fisheries	117
MSC Principle 3	119
12. Governance and Policy	119
12.1 Legal and / or Customary Framework	119
12.1.1 Compatibility of Laws or Standards with Effective Management	119
12.1.2 Resolution of Legal Disputes	128
12.1.3 Respect for Rights	128
12.2 Consultation, Roles and Responsibilities	131
12.2.1 Roles and Responsibilities	131
12.2.2 Consultation Processes	135
12.2.3 Participation	139
12.3 Long-term Objectives	140
12.4 Incentives for Sustainable Fishing	143
13. Fishery-Specific Management System	146
13.1 Harvest Strategy	146
13.2 Fishery-Specific Objectives	146
13.2.1 Ecological Sustainability	147
13.2.2 Social and Economic Objectives	149
13.3 Decision-Making Processes	150
13.3.1 Annual Processes	151
13.3.2 Long-Term Processes	151

13.3.3 Responsiveness of Processes	152
13.3.4 Use of Precautionary Approach.....	153
13.3.5 Accountability and Transparency.....	153
13.3.6 Approach to Disputes	156
13.4 Compliance and Enforcement	156
13.4.1 Monitoring, Control and Surveillance Implementation.....	158
13.4.2 Applying Sanctions	167
13.4.3 Level of Compliance	170
13.5 Research Plan	173
13.6 Monitoring and Management Performance Evaluation.....	180
13.6.1 Review of the Management System	181
14. References	183
14.1 General References (Sections 1 – 5)	183
14.2 MSC Principle 1 References (Sections 6 – 8)	188
14.3 MSC Principle 2 References (Sections 9 – 11)	190
14.4 MSC Principle 3 References (Sections 12 – 13)	193
15. Appendices	197
Appendix A – Blue Swimmer Crab Research Summary	197
Appendix B – 2014-15 Ecological Risk Assessments	212
Appendix C – 2010 External Review of Blue Swimmer Crab Research	243
Appendix D – Commercial Catch and Effort Returns.....	252
Appendix E – Waterbirds in the Peel-Harvey Estuary	254
Appendix F – MLFA Code of Practice	257
Appendix G – Compliance Daily Patrol Contacts Form	261
Appendix H – Blue Swimmer Crab Published Article.....	262
Appendix I – Additional References Provided to Assessment Team.....	263

List of Tables

Table 2.1. Growth parameters estimated by fitting the von Bertalanffy growth curve to the lengths at ages of female and male sea mullet (Gaughan <i>et al.</i> 2006).....	5
Table 4.1. Adjusted estimates of total recreational catch (t) of blue swimmer crabs in the Peel-Harvey Estuary in 1998/99, 2007/08 and 2011/12 (IFAAC in prep.)	33
Table 5.1. Retained catches (in tonnes, t) of sea mullet by other commercial fisheries in the West Coast Bioregion (WCB) that target the same stock as that in the WCEMF Area 2.	35
Table 5.2. Retained catches (in tonnes, t) of blue swimmer crabs by other commercial fisheries in south-western WA that target the same stock as that in the WCEMF Area 2.	36
Table 7.1. ANOVA table (Type I and Type III sum of squares, SS) for the fitted model used to describe monthly catch rate of sea mullet in the WCEMF Area 2.	52
Table 7.2. PSA scores for sea mullet in the WCB.	53
Table 7.3. ANOVA table (Type I and Type III sum of squares, SS) for the fitted model used to describe monthly catch rate of blue swimmer crabs in the WCEMF Area 2.	55
Table 7.4. PSA scores for blue swimmer crabs in south-west WA.	58
Table 8.1. Summary of information available to support the harvest strategy for sea mullet in the PHE.	69
Table 8.2. Summary of information available to support the harvest strategy for blue swimmer crabs in the PHE.....	70
Table 8.3. Research sampling methods, periods and sites in the PHE region. (Refer to Figure 8.3 for site code locations.)	77
Table 9.1. Retained species catches (kg) for the WCEMF Area 2 (haul and gillnet sectors) for 2004 – 2013. Dark blue shading indicates target (P1) species and light blue shading indicates main retained species (i.e. > 5 % total retained catch based on the average catch for 2009 – 2013);	82
Table 9.2. Per cent (%) of the total average catch for each species by net type and combined overall catch over the five-year period from 2009 through 2013.	84
Table 9.3. All retained species (t) for the WCEMF Area 2 (trap sector) 2004/05 – 2013/14. Dark blue indicates target (P1) species. Octopus catches reflect ‘live weight’ catch reports.	87
Table 9.4. Summary of bait usage in the WCEMF Area 2 (trap sector). The number of traps per day is an average of the number of traps used per year.	88

Table 9.5. Total retained and discarded species (by number) by recreational blue swimmer crab fishers using drop nets in 1998 – 1999 and 2007 – 2008. Blue shading indicates target (P1) species. Per cent (%) total catch calculated across all four surveys combined.....	89
Table 9.6. Sample of bait species and amount used (number) by recreational drop net fishers in the PHE. ‘U’ indicates reported species, but unknown number used.....	90
Table 9.7. Total retained and discarded species (by number) by recreational blue swimmer crab fishers using scoop nets in 1998 – 1999 and 2007 – 2008. Blue shading indicates target (P1) species. Per cent (%) total catch calculated across all four surveys combined.....	91
Table 9.8. Observed haul net catch in the WCEMF Area 2 in March 2015	93
Table 9.9. Estimated total weight (kg) and proportion (%) of total catch comprised by each captured species during three observer trips	93
Table 9.10. Bycatch species and catch observed in the PHE (trap) fishery for blue swimmer crabs during on-board catch monitoring conducted between July 2007 and December 2013. *Total number is an estimate for the entire period (2007 – 2013) based on observed catches per trap.	94
Table 12.1. WAFIC's Commercial Fisheries Consultation Operational Principles.....	134
Table 13.1. Short-term ecological objectives in place for each component of the finfish fishery in the PHE. The performance indicators and reference levels used to assess the extent in which the fishery has met these objectives is provided in the <i>Finfish Resources of the Peel-Harvey Estuary Harvest Strategy</i>	148
Table 13.2. Short-term ecological objectives in place for each component of the blue swimmer crab fishery in the PHE. The performance indicators and reference levels used to assess the extent in which the fishery has met these objectives is provided in the <i>Blue Swimmer Crab Resource of the Peel-Harvey Estuary Harvest Strategy</i>	149
Table 13.3. Progress of decision-making undertaken as the WCEMF moved from an interim managed to a managed fishery in 2013 – 2014 (as required by the FRMA)	155
Table 13.4. Process of decision-making undertaken as changes were made to recreational fishing rules in WA.....	156
Table 13.5. Management measures and instrument of implementation for the West Coast Estuarine Managed Fishery: Area 2.....	164
Table 13.6. Management measures and instrument of implementation for the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery.	165
Table 13.7. Summary of detected offences in the WCEMF Area 2 from 2010/11 to 2013/14.	170

Table 13.8. Summary of detected offences by recreational fishers in the PHE from 2010/11 to 2013/14.	170
Table 13.9. Examples of research plan development, research undertaken, research results and how they relate to Principles 1, 2 and 3.	177

List of Figures

Figure 1.1. Schematic and aerial photo of the Peel-Harvey Estuarine system.	2
Figure 2.1. The sea mullet.....	3
Figure 2.2. The blue swimmer crab.	6
Figure 3.1. The boundaries, extent and closed areas of the West Coast Estuarine Managed Fishery Area 2: the Peel-Harvey Estuary and affluents.....	13
Figure 3.2. Schematic of typical fishing net, such as those used by commercial fishers in the WCEMF Area 2	14
Figure 3.3. Photos of typical haul net fishing activities: (a) setting the net; (b and c) hauling the net by hand; (d) fish caught in mesh; and (e) sample of sea mullet catch.	15
Figure 3.4. Commercial crab trap used in the WCEMF Area 2 showing escape gap	17
Figure 3.5. Seasonal plots showing start locations of trap lines sampled during commercial catch monitoring surveys aboard commercial vessels in the WCEMF Area 2 between March 2007 and November 2014 inclusive. Seasons are defined as: Summer (Dec – Feb), Autumn (Mar – May), Winter (Jun – Aug) and Spring (Sep – Nov).....	18
Figure 3.6. Total annual gillnetting effort and annual sea mullet catch by gillnet in the WCEMF Area 2 between 1976 and 2013.....	19
Figure 3.7. Total annual haul netting (includes early records of beach seining and beach hauling) effort and annual sea mullet catch by haul net in the WCEMF Area 2 between 1976 and 2013.....	20
Figure 3.8. Annual commercial blue swimmer crab catch (tonnes, t) in the WCEMF Area 2 by fishing method, and overall effort (fisher days) irrespective of method, from 1980/81 to 2013/14. Total catch (■); crab traps (—); gillnets (—); other methods (---); effort (fisher days) (●●). Annual catch and effort is presented by financial year (1 July – 30 June).....	21
Figure 3.9 Annual commercial blue swimmer crab trap catch (tonnes, t) (■) in the WCEMF Area 2, indicating effort (trap lifts x 1000) (●●) and nominal catch rate (catch per unit effort; CPUE, kg / traplift) (----) between 1995/96 and 2013/14. Data is presented by financial year (1 July – 30 June).....	21
Figure 3.10. Mean monthly commercial blue swimmer crab catch (tonnes, t) from the WCEMF Area 2 using gillnets (■; 1980–1995) and hourglass traps (■; 1996–2013). Monthly calculations for September and October are based on data prior to 2007 as a seasonal closure was introduced in 2007 that spans these months.	22

Figure 3.11. Monthly blue swimmer crab catch (tonnes, t) (■), effort (trap lifts x 1000) (●●●) and CPUE (kg / traplift) (---) for the 2013/14 fishing season (1 November – 31 August) in the WCEMF Area 2.	23
Figure 3.12. Comparison of blue swimmer crab CPUE (kg/traplift) for the 2013 fishing season vs historical data in the WCEMF Area 2. (---) pre-2009/10 season (1995/96-2008/09), (—) 2009/10 season, (—) 2010/11 season, (—) 2011/12 season, (—) 2012/13 season (—) 2013/14 season.	23
Figure 3.13. Boat ramps and estimated main recreational blue swimmer crab fishing areas of the PHE. Pink shading indicates Coodanup Scooping Area; green shading indicates Peel/Harvey Scooping Area; and yellow shading indicates Harvey Scooping Area.....	25
Figure 3.14. Wire mesh bottom baited drop net used by boat- and shore-based recreational fishers in the PHE to target blue swimmer crabs.....	26
Figure 3.15. Scoop net used primarily by shore-based recreational fishers in the PHE to target blue swimmer crabs	27
Figure 5.1. Effect of 50 % increase and decrease of seagrass biomass on the relative biomass of blue swimmer crabs in the PHE	39
Figure 5.2. Effect of phytoplankton blooms, simulating an increase in biomass of microscopic algae by factor 10, on the target fish species yelloweye mullet (<i>Aldrichetta forsteri</i>) and sea mullet (<i>Mugil cephalus</i>) in the PHE.	39
Figure 5.3. Location of the proposed Point Grey Development and Marina.....	42
Figure 6.1. Annual standardised commercial catch rate (kg / 100 m netting hour) of sea mullet in the WCEMF Area 2 relative to the associated reference points.	44
Figure 6.2. Annual commercial catch (tonnes) of sea mullet in the WCEMF Area 2 relative to the associated reference points.....	45
Figure 6.3 Annual standardised commercial catch rate (kg / traplift) of blue swimmer crabs in the WCEMF Area 2 relative to the associated reference points.	46
Figure 6.4. Annual commercial catch (tonnes) of blue swimmer crabs in the WCEMF Area 2 relative to the associated reference points..	47
Figure 7.1. Annual standardised catch rate for sea mullet targeted by the “primary” vessels in the WCEMF Area 2 using haul and gillnets, with 95 % confidence intervals (shaded and grey areas).	51
Figure 7.2. Annual raw and standardised catch rates for sea mullet targeted by the “primary” vessels in the WCEMF Area 2 using both methods (haul and gillnetting combined) with 95 % confidence intervals (grey area).	52

Figure 7.3. Raw and standardised catch rates (CPUE) for blue swimmer crabs targeted by the current commercial vessels in the WCEMF Area 2, with 95 % confidence intervals (grey area).....	56
Figure 7.4. Mean (± 1 SE) catch rates (crabs / traplift) of juvenile crabs (Males < 87.1 mm CW, Females < 86.9 mm CW) sampled in Channel Estuary sites (EC1, EC2, EC3) from June to August.	57
Figure 7.5. Mean (± 1 SE) catch rates (crabs / traplift) of sexually mature female crabs (≥ 86.9 mm CW) sampled in Channel Estuary sites (EC1, EC2, EC3) from June to November.....	57
Figure 8.1. Flowchart of generic harvest control rules for the sea mullet and blue swimmer crabs resources of the PHE.	66
Figure 8.2. Locations of trap lines sampled during commercial catch monitoring surveys aboard commercial vessels in the WCEMF Area 2 between March 2007 and June 2014. Data is presented over the financial year; July to June.	72
Figure 8.3. Map of the PHE detailing fisheries-independent research sampling sites inside and outside the estuary and de Lestang (2002) trap sites. Data from current sampling sites compared to data from de Lestang (2002) sites are indicated by the broken blue line. Sites PE1-6 and 201/275 were compared for Peel region; sites HE1-3 and 145 were compared for Dawesville Channel-Harvey region; sites HE4-6 and 129 were compared for Deep-Harvey region.	76
Figure 8.4. Hourglass research crab trap used in the fishery-independent monitoring surveys in the PHE.....	77
Figure 9.1. Annual commercial gillnet catch rate (kg per fishing day in July – September) of cobbler in the PHE 1990 – 2013	86
Figure 9.2. Mean distribution of total macroalgae biomass for November/December 2009 in the PHE	101
Figure 9.3. Mean distribution of seagrass biomass for November/December 2009 in the PHE.	102
Figure 9.4. Map of the PHE showing the location of the nearshore study sites and the habitat type to which each site was assigned by CLUSTER and SIMPROF procedures; sites at which fauna and water quality measurements were collected (bold text in brackets); and the location, number and habitat of new nearshore sites chosen to demonstrate the use of the habitat prediction procedure	104
Figure 9.5. Recreational blue swimmer crab fishing ‘hotspots’ in the PHE based on anecdotal information provided by compliance staff in 2014.....	107
Figure 9.6. Simplified food web of the PHE	110

Figure 9.7. Conceptual model of the effects of nutrient inflows on the PHE	110
Figure 12.1. Outline of risk-based planning cycle used by the Department to determine annual priorities and activities.	127
Figure 12.2. Broad fisheries management consultation framework in WA	137
Figure 13.1. Comparison of recreational fishing compliance contact rates in the PHE at different times of the day over three different time periods.	167
Figure 13.2. Overview of the development of the Research Plan for the PHE fishery..	175

Acronyms and Abbreviations

AAC – Aquatic Advisory Committee

AFMA – Australian Fisheries Management Authority

AFZ – Australian Fishing Zone

ARMA – Aquatic Resources Management Bill/Act

CAES – Catch and Effort Statistics

CEO – Chief Executive Officer

CSA – Consequence Spatial Analysis

CW – Carapace width

DBIF – Development of Better Interests Fund

DotE – Department of the Environment (Commonwealth)

DoF – Department of Fisheries (Western Australia)

DG – Director General

DPaW – Department of Parks and Wildlife (Western Australia)

DPC – Daily Patrol Contact

EBFM – Ecosystem Based Fisheries Management

EMS – Environmental Management System

EPA – Environmental Protection Authority

EPBC – Environment Protection and Biodiversity Conservation (Act)

ESD – Ecologically Sustainable Development

ETP – Endangered, threatened and protected (species)

FAS – Fisheries Adjustment Schemes (Act)

FMO – Fisheries and Marine Officers

FMP – Fisheries Management Paper

FOP – Fisheries Occasional Paper

FRDC – Fisheries Research and Development Corporation

FRMA – Fish Resources Management Act

FRMR – Fish Resources Management Regulations

FRR – Fisheries Research Report

GVP – Gross value of production

IFAAC – Integrated Fisheries Allocation Advisory Committee

IFM – Integrated Fisheries Management

MAC – Management Advisory Committee

MCS – Monitoring, control and surveillance

MLFA – Mandurah Licensed Fishermen’s Association

MSC – Marine Stewardship Council

NT – Native Title (Act)

OCP – Operational Compliance Plan

OCS – Offshore Constitutional Settlement

PAP – Prosecution Advisory Panel

PHCC – Peel-Harvey Catchment Council

PHE – Peel-Harvey Estuary

PSA – Productivity Susceptibility Analysis

QL – Qualification level

RFBL – Recreational Fishing from Boat Licence

RMAD – Research, Monitoring, Assessment and Development (Plan)

RNFL – Recreational Net Fishing Licence

SAT – State Administrative Tribunal

SLA – Service Level Agreement

SICA – Scale Intensity Consequence Analysis

SOP – Standard Operating Procedure

TL – Total length

UoC – Unit of Certification

VFAS – Voluntary Fishery Adjustment Scheme

WA – Western Australia

WAFIC – Western Australian Fishing Industry Council

WAMSI – Western Australian Marine Science Institution

WCB – West Coast Bioregion

WCEMF – West Coast Estuarine Managed Fishery

1. Aquatic Environment

The Peel-Harvey Estuary (PHE) is located 80 km south of Perth in the south-west region of WA. This region has a Mediterranean climate comprising cool, wet winters and hot, dry summers (Gentilli 1971). The mean annual rainfall in the vicinity of the PHE is ca. 900 mm, 70 – 80 % of which falls during the Austral winter between May and October. The coastline is microtidal (Davies 1964) and has a mean tidal range of ca. 0.6 m (Valesini *et al.* 2010).

There are two distinct parts of the PHE system, known as Peel Inlet and Harvey Estuary (although they are both estuarine and both inlets). The Peel Inlet and the Harvey Estuary are joined by a narrow channel through the Point Grey Sill, and the estuary is connected to the Indian Ocean via a natural entrance channel (the Mandurah Channel) in the northern Peel Inlet and an artificial entrance channel (the Dawesville Channel) which is located in the northern part of Harvey Estuary (Figure 1.1).

The shallow waters of the PHE support extensive stands of macroalgae and seagrass. These plants, in combination with high phytoplankton productivity, support large populations of small invertebrate animals. The high plant and invertebrate productivity is the basis of a food chain that supports a number of fish, invertebrates and mammals. In the 1970s – 1980s, however, increasing inputs of nutrients from surrounding agricultural land added to this high natural productivity and led to a substantial increase in algal biomass in the PHE. The widespread macrophyte growth and toxic algal blooms had a large influence on the commercial fisheries in the estuary, particularly by causing fouling of fishing nets with weed and with the reduced visibility making it difficult for fishers to locate schools of fish. The deterioration of the aquatic environment promoted research of the ecosystem (e.g. Hodgkin *et al.* 1981) and in 1994, an artificial entrance channel to the estuary (the Dawesville Channel) was opened to increase water exchange throughout the estuary and thereby improve water quality (see Section 5.3.1.1 for more detail on impacts of this channel).

Over 50 species of fish have been recorded in the PHE, the majority being marine species that enter the estuary as juveniles (marine estuarine-opportunists; Potter *et al.* 1998; Hale & Butcher 2007). Common commercial and recreational species in the estuary include sea mullet (*Mugil cephalus*), yelloweye mullet (*Aldrichetta forsteri*), estuary cobbler (*Cnidogobius macrocephalus*, hereafter referred to as ‘cobbler’), King George whiting (*Sillaginodes punctata*), black bream (*Acanthopagrus butcheri*) and tailor (*Pomatomus saltatrix*; Hale & Butcher 2007).

The estuary was listed as a Ramsar Wetland of International Importance in 1990, as part of the larger Peel-Yalgorup Wetland System, and is considered to be an internationally-significant habitat for waterbirds.

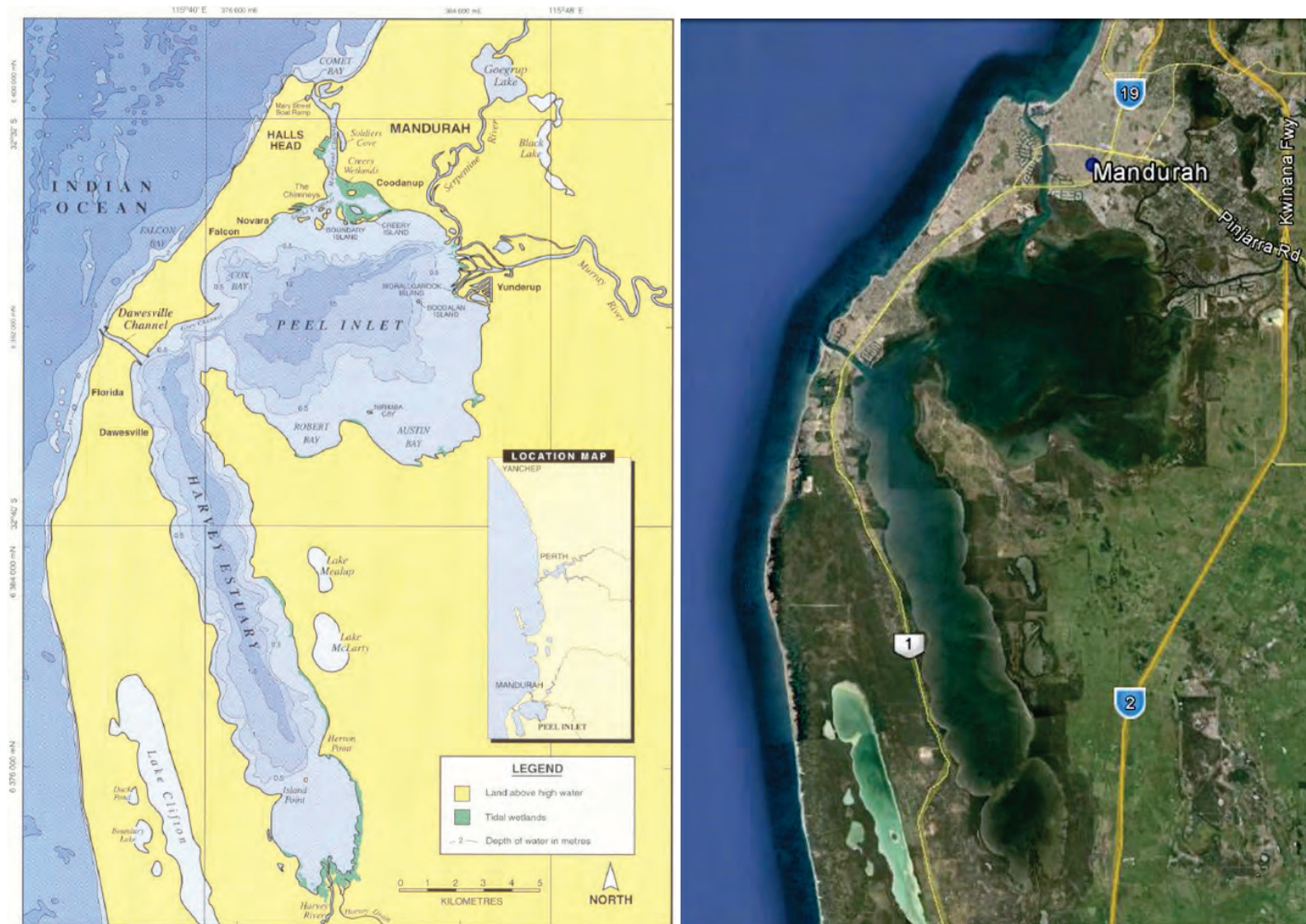


Figure 1.1. Schematic and aerial photo of the Peel-Harvey Estuarine system (Source: Department of Water 1998; Google Earth 2014).

2. Target Species / Stock Description

2.1 Sea Mullet



Figure 2.1. The sea mullet. Illustration © R. Swainston (www.anima.net.au).

2.1.1 Taxonomy and Distribution

The sea mullet (*Mugil cephalus*, Figure 2.1) is a member of the Family Mugilidae (mulletts).

Sea mullet have a worldwide tropical distribution and occur almost entirely between the latitudes of ~42 °N and 42 °S (Thomson 1963; Rossi *et al.* 1998). In Australia this species appears to be most abundant from approximately 25 °S to 35 °S along the eastern and western coastlines. Sea mullet occur in marine, estuarine and fresh waters, tolerating salinities of 0 – 80 ppt (Thomson 1963).

2.1.2 Stock Structure

Due to the broad dispersal of eggs and larvae by ocean currents, combined with adult pre-spawning migrations, sea mullet along the lower west and south coasts of WA are considered to represent a genetically homogeneous stock. Taking a precautionary management approach, however, sea mullet in the West Coast Bioregion (WCB, see Fletcher & Santoro 2014), which includes the PHE, is managed as a separate stock from populations in the neighbouring Gascoyne Coast and South Coast bioregions.

2.1.3 Life History

Sea mullet is a gonochoristic species, which grows to a maximum size of ~600 mm total length (TL) and attain a maximum age of 12 years (Smith & Deguara 2002; Gaughan *et al.* 2006).

When sea mullet reach sexual maturity at approximately 3 – 4 years of age (Chubb *et al.* 1981; Virgona *et al.* 1998), they typically undergo a migration from estuaries to open waters to spawn during late summer and autumn (see below). The eggs of sea mullet are pelagic and hatch after approximately 48 hours (Thomson 1963; Smith & Deguara 2002). After hatching, larvae sink for the first 10 days and then undergo positive phototaxis towards surface waters (Liao 1974). Leis and Carson-Ewart (2000) provide a description of the larval stages of sea mullet. At 20 – 30 mm TL, juveniles typically enter estuaries where they remain until the onset of maturity.

2.1.3.1 Movements and Important Habitats

Juvenile sea mullet typically inhabit estuaries, where they associate with shallow weed beds and bare substrate, while adults are found in estuaries, shallow coastal waters and marine embayments (Chubb *et al.* 1981; Harrison & Senou 1999; Smith 2006). Due to the tolerance of this species to a wide range of salinities, sea mullet can occur in the upper reaches of estuaries (Chubb *et al.* 1981).

In most regions, mature sea mullet undergo a pre-spawning migration. This usually involves moving from an estuary to coastal waters in large schools and then traveling northwards, against the prevailing current, along the open coastline to their spawning grounds. The northwards movement of sea mullet during autumn is most pronounced on the east coast of Australia, however, it also occurs along the south-west coast of Australia. The cue to commence migration on the south-west coast of WA appears to be persistent easterly winds during late summer/autumn (Fraser 1953).

Annual migrations of sea mullet up to 724 km have been recorded on the east coast, although 100 km is a more typical distance (Smith & Deguara 2002). Tagging studies of sea mullet on the east and west coasts have not detected any significant southward movement, and therefore fish are assumed to disperse and swim into nearby estuaries after spawning.

2.1.3.2 Reproduction

The mean length at maturity (i.e. L_{50}) for sea mullet in temperate WA was estimated by Gaughan *et al.* (2006) as 373 mm TL. This corresponds to an age at maturity of 3 – 4 years (Virgona *et al.* 1998), with females maturing at a greater age and length than males.

Sea mullet spawn between February and September on the lower west coast of WA (Chubb *et al.* 1981; Orr 2000; Potter *et al.* 2000; Gaughan *et al.* 2006). It is believed that spawning only occurs at sea, with no spawning activity inside estuaries (Orr 2000; Crisafulli 2008).

2.1.3.3 Size-Fecundity Relationships

Sea mullet has a determinate fecundity. The relationship between fecundity (F) and total length (TL , mm) for this species in Queensland was described by Grant and Spain (1975) as

$$F = 0.0007 TL^{3.50}.$$

2.1.3.4 Factors Affecting Recruitment of Juveniles

There is no published information about factors affecting the recruitment of sea mullet. As spawning of sea mullet occurs outside the estuary, the strength of ocean currents such as the Leeuwin Current is likely to have a large influence on recruitment of this species.

2.1.3.5 Weight-Length Relationships

The relationship between total wet weight (W , g) and total length (TL , mm) for sea mullet on the temperate lower west coast of WA was described by Gaughan *et al.* (2006) as

$$W = 0.00000472 TL^{3.15}.$$

2.1.3.6 Age and Growth

Sea mullet were sampled in waters off south-western WA between 1999 and 2002 as part of a study to develop a recruitment index for several commercially and recreationally important fish species. All sea mullet were aged by counting opaque zones in sectioned otoliths and marginal increment analysis was used to confirm that the opaque zones are formed annually (Gaughan *et al.* 2006). Annulus formation occurred in the months between August and December, with October being the main ring deposition month. A birth date of 1 June was assigned to sea mullet, based on the peak in the gonadosomatic index (Gaughan *et al.* 2006).

The growth of female and male sea mullet on the south coast and lower west coast of WA was estimated by Gaughan *et al.* (2006) by fitting a von Bertalanffy growth function assuming that the mean length (L , mm) of sea mullet is zero at age zero. Female sea mullet grow substantially larger than males (Table 2.1). The growth of this species was also found to differ significantly between the lower west coast and south coast of WA, with this species growing to a larger size on the south coast (Table 2.1).

Table 2.1. Growth parameters estimated by fitting the von Bertalanffy growth curve to the lengths at ages of female and male sea mullet (Gaughan *et al.* 2006).

Region	Sex	L_{∞} (mm)	k (year ⁻¹)	t_0 (years)	Sample size
West	Females	508.9	0.590	Fixed at zero	170
	Males	398.0	0.793	Fixed at zero	177
South	Females	588.4	0.352	Fixed at zero	230
	Males	446.6	0.552	Fixed at zero	245

2.1.3.7 Diet

Sea mullet feeds on detritus (often ingesting a large amount of substrate in the process), diatoms, algae and occasionally crustaceans and bivalves (Lenanton 1978; Orr 2000).

2.1.3.8 Natural Mortality

Estimates of natural mortality (M) are available for sea mullet populations, but values are extremely variable and considered unreliable (Smith & Deguara 2002). Based on a maximum age (t_{\max}) of 12 years for this species and using Hoenig's (1983) mortality equation for fish ($M = \exp(1.46 - 1.01 \cdot \ln(t_{\max}))$), an M estimate of 0.35 year⁻¹ is obtained for sea mullet.

2.1.3.9 Parasites

A bacterial disease in estuarine fish stocks known as "red spot" has been reported to occur in sea mullet in south-eastern Queensland (Burke & Rodgers 1981). A detailed account of the various parasites that affect mullet species, with emphasis on aquaculture, is provided by Paperna and Overstreet (1981).

2.2 Blue Swimmer Crab



Figure 2.2. The blue swimmer crab. Illustration © R. Swainston (Source: www.anima.net.au).

2.2.1 Taxonomy and Distribution

The blue swimmer crab (Figure 2.2; formerly *Portunus pelagicus* [Linnaeus 1758; A. Milne Edwards 1861]) has recently been reclassified as *Portunus armatus* (Lai *et al.* 2010), but there is no ambiguity in the classification of the species in catch records.

Blue swimmer crabs are widely distributed throughout the Indo-West Pacific, ranging from east Africa to Japan, Tahiti and northern New Zealand (Kailola *et al.* 1993). In Australia, the species inhabits coastal waters from the south coast of WA, around the north to the south coast of New South Wales. They are also found in the warmer waters of the South Australian gulfs.

2.2.2 Stock Structure

Genetic studies have indicated that blue swimmer crab assemblages on the WA coast become more distinct from north to south, with those in the south-west region (i.e. Swan-Canning Estuary, Cockburn Sound, Warnbro Sound, PHE and Geographe Bay) forming a homogenous, but highly distinctive, group separate to those stocks further north in Shark Bay and Exmouth Gulf (Chaplin *et al.* 2001; Sezmiş 2004; Chaplin & Sezmiş 2008).

The blue swimmer crab in south-western WA is likely to be represented by a series of overlapping biological stocks, with gene flow between geographical regions largely controlled by the degree of water exchanges (Sezmiş 2004). Chaplin and Sezmiş (2008) confirmed that genetic compositions of the assemblages of blue swimmer crabs in Cockburn Sound and the Swan-Canning Estuary were homogenous and genetically distinct from other south-western assemblages, including crabs in the PHE. This is likely due to the enclosed nature and hydrology of Cockburn Sound and the life cycle of blue swimmer crabs generally occurring wholly within this embayment.

Given that the Leeuwin Current flows north to south and the greater potential for mixing of larvae among the more closely spaced embayments south of Cockburn Sound, the blue swimmer crab assemblages in Warnbro Sound, the PHE and in coastal waters between Mandurah to Bunbury are highly likely to be part of the same genetic stock. There is not only

highly likely that mixing of larvae between fishing grounds is occurring in this region, but the close proximity of these areas, aided by a continuous limestone reef system connecting these regions, will also accommodate movement of adult crabs.

2.2.3 Life History

The reproductive cycle of blue swimmer crab populations along the WA coast is strongly influenced by water temperature (de Lestang *et al.* 2010). The waters of the lower west coast are at the southern extreme of this species temperature tolerance, and reproduction is restricted to the warmer months, with mating occurring in late-summer when females are soft-shelled (Kangas 2000; de Lestang *et al.* 2010).

Mature males moult some weeks before the maturing females, and each male carries a female clasped beneath him for 4 – 10 days until she moults and mating occurs. Female crabs store the sperm for a number of months until eggs are fertilised and spawned (Penn 1977; Smith 1982). Incubation takes 10 to 18 days, depending upon water temperature, and the larval phase extends for up to six weeks (Kangas 2000). Females produce between 180,000 and two million eggs, which hatch into its larval phase known as a zoea. In crab stocks exposed to the open ocean, larvae can drift as far as 60 km out to sea, before returning to settle inshore (Kangas 2000).

Blue swimmer crabs moult frequently during the juvenile phase and growth is rapid. Individuals attain commercial size at around 12 – 15 months of age, with the minimum legal size (127 mm carapace width [CW]) set sufficiently above the mean size at maturity allowing females to spawn at least once before being available for retention.

2.2.3.1 Movements and Important Habitats

Blue swimmer crabs live in a wide range of inshore and continental shelf habitats, including sandy, muddy or algal and seagrass habitats, from the intertidal zone to waters of at least 50 m in depth (Williams 1982; Edgar 1990). The majority of the commercially and recreationally-fished stocks along the WA coast are concentrated in the coastal embayments and estuaries between Nickol Bay (~ 21° S) in the north and Geographe Bay (~ 34° S) in the southwest.

Movements of blue swimmer crabs can be characterised by changes in temperature and salinity and often takes place in late autumn to winter from shallower to deeper waters (Kangas 2000; Potter & de Lestang 2000; Aguilar *et al.* 2005). In estuaries such as the PHE, movements of crabs are also influenced by the inflow of fresh water following the onset of winter rains (Potter *et al.* 1998). Most female juvenile crabs will exit the estuaries primarily between June and September, and ovigerous sub-legal females will then spawn for the first time in oceanic waters (Johnston *et al.* 2014a). The movement of crabs into oceanic waters may play an important role in the survival of first stage zoea (Smith 1982) due to increased levels of dissolved oxygen and increased larval distribution.

Most sub-legal crabs (i.e. those < 127 mm CW) will re-enter estuaries and rivers at the end of spring and throughout summer, with males re-entering between November and January and

females re-entering between January and March (Johnston *et al.* 2014a). Some legal (1+ class) crabs will remain outside of the estuary or move to adjacent estuaries or embayments.

2.2.3.2 Reproduction

The size at which blue swimmer crabs reach maturity is generally inversely related to water temperature, thus varies considerably between water bodies of the south-west coast and Shark Bay in the north (de Lestang *et al.* 2003a). In the PHE, 50 % of females have reached maturity at a size of 97.5 mm CW, with 50 % of males being mature at 86 mm CW (de Lestang *et al.* 2003a).

In south-west WA, females reach maturity and undergo a pubertal moult in late summer / autumn of their first year (6 – 10 months). During this pubertal moult, the abdominal flap changes from a triangular to oval shape and from being tightly to loosely-fixed to the cephalothorax (Fisher 1999; de Lestang *et al.* 2003a). Male courtship is triggered by a pheromone released by the female (Meagher 1971), and males moult some weeks before the female. While soft, females mate and retain spermatophores over the winter months before spawning occurs between October and January (Penn 1977; Smith 1982).

2.2.3.3 Size-Fecundity Relationships

The amount of eggs produced by female blue swimmer crabs varies according to size, with larger crabs being able to produce greater number of eggs, as well as producing multiple batches within a spawning period (de Lestang *et al.* 2003a). In Cockburn Sound, de Lestang *et al.* (2003a) found that the number of eggs recorded for a single batch of eggs under the abdomen of a female, ranged from 68 450 in a crab with a 84 mm CW to 324 440 in a crab with a 154 mm CW. The relationship between batch fecundity (*BF*) and size (*CW*, mm) was described by de Lestang *et al.* (2003a) as

$$\ln BF = 1.8208 \ln CW + 3.2862.$$

The longer intermoult period between copulation and egg extrusion in the older crabs accounts for the greater number of egg batches produced by larger than small crabs (de Lestang *et al.* 2003a).

2.2.3.4 Factors Affecting Recruitment of Juveniles

Levels of recruitment to many of the crab fisheries fluctuate considerably between years. While the causes of these variations are not fully understood, it is considered most likely due to environmental influences on spawning success and larval survival through to recruitment.

In a study of blue swimmer crabs in Cockburn Sound, recruitment was strongly correlated with the coastal water temperature, with strong recruitment being recorded from years with higher than average water temperatures in the months of August and September, prior to spawning (de Lestang *et al.* 2010). This was supported by Johnston *et al.* (2011a, b) who recorded poor recruitment from four years where lower than average temperatures were reported in months prior to spawning; a major contributing factor in the decline of the crab fishery in Cockburn Sound. Furthermore, while water temperatures encountered by developing larvae in Cockburn Sound influence survival, the timing of spawning has also

been found to significantly influence recruitment success, with stronger recruitment recorded during years with early (August / September) spawning (de Lestang *et al.* 2010).

2.2.3.5 Weight-Length Relationships

The relationship between the body weight (W , g) and carapace width (CW , mm) of blue swimmer crabs in Cockburn Sound, using data for crabs collected in the late 1990s and covering their full size range, is described as

$$W = 0.00004 \times CW^{3.1281} (R^2 = 0.962, n = 2478) \text{ (Lestang *et al.* 2003b).}$$

In juveniles and pre-adult blue swimmer crabs of the Mandapam Coast in India, weight gain is almost uniform; females were slightly heavier than males until they attained 120-125 mm CW (Josileen 2011). Thereafter males were heavier than females at any given length, which supports the tendency in WA for male crabs to be heavier than females (Potter *et al.* 1983).

2.2.3.6 Age and Growth

Growth of blue swimmer crabs is comparable between estuaries and embayments of the temperate south-west. In a study by de Lestang *et al.* (2003c), the size of crabs at the end of their first year of life were virtually identical in these regions, suggesting that the rate of growth is largely genetically determined. Growth is highly seasonal and is generally dependent on temperature and salinity (Fisher 1999; de Lestang *et al.* 2003c). Growth tends to be limited during winter months (Sumpton *et al.* 1989), whilst the size of crabs did not change significantly between late autumn (May) and mid-spring (October) in the PHE (de Lestang *et al.* 2003c).

Juvenile crabs in the PHE are recruited into the fishery in January and the patterns of growth during this first year are relatively consistent. At approximately 10 months they reach a size of ~ 95 mm CW (late spring) and as growth increases over summer, they reach a legal size of ~ 130 mm CW by early autumn (March; 15 months; de Lestang *et al.* 2003c).

The pubertal moult (and hence maturity) occurs within their first year between 80 and 100 mm CW and coincides with copulation. Females retain sperm over the winter months until they spawn in the following spring. The retention of sperm is facilitated by the absence of moulting and hence restriction of growth over winter (de Lestang *et al.* 2003c). After puberty, moulting in female crabs changes from being temperature-dependent to being annual, thus adults moult just once a year.

Although blue swimmer crabs can attain a maximum age of ~ 3 years (Smith & Sumpton 1987), most animals will have died through natural or fishing mortality by 20 months of age in WA (Potter *et al.* 2001). Relatively few crabs are expected to survive beyond 18 months (de Lestang *et al.* 2003c). Blue swimmer crabs in WA can grow to a maximum size of approximately 200 mm CW (de Lestang *et al.* 2003c).

2.2.3.7 Diet

The diet of blue swimmer crabs is highly variable dependent on size and shell state, with crabs that have recently moulted ingesting a higher proportion of calcareous material, such as

that from the small bivalve *Arthritica semen* (de Lestang *et al.* 2000). The diet of intermoult crabs tends to be more diverse with the three main diet categories being small bivalves, gammarid amphipods and polychaetes. The blue swimmer crab does not, however, feed immediately prior to, or just after, moulting. As the shell hardens, feeding on organic material is greatest during the intermoult period (Williams 1982).

2.2.3.8 Natural Mortality

No specific study to determine the natural mortality of blue swimmer crabs in WA waters has yet been undertaken. However, it is suggested that in areas of exploited fishing stocks, crabs have died either through natural mortality or due to fishing pressure by the time they are 18 – 20 months old (Potter *et al.* 2001; de Lestang *et al.* 2003c).

2.2.3.9 Parasites

Sacculina granifera Boschma is a parasitic barnacle that infects blue swimmer crabs, bringing about a number of major changes in the host crab, including degeneration of the sex organs in both sexes and modification of the male crab to a more female form. Infection usually results in castration for both sexes, however, infected hosts are still capable of mating and some females are still able to produce a clutch of eggs.

Infestation is common in northern Australian waters, and is found regularly in commercial trap catches along the Pilbara coast (Bellchambers *et al.* 2005); however, incidence of *S. granifera* infestation is extremely rare south of Exmouth Gulf, with only two infected crabs captured during the extensive fishery-independent research trawl and commercial monitoring programs conducted by the WA Department of Fisheries (the Department, DoF) in the PHE and Cockburn Sound.

3. Fishery Information

3.1 Commercial Fishing Activities

3.1.1 Development of the Commercial Fishery

The commercial finfish net fishery in the PHE was first established in the mid-1800s (Bradby 1997). This fishery is one of the oldest in Australia, with up to 150 fishers historically operating in family-based fishing units to supply fresh fish to the local Perth and Fremantle markets (Mandurah Licenced Fishermen's Association [MLFA] 2008).

Although abundant within the estuary, blue swimmer crabs were typically ignored by the commercial fishers as there was no market for them during the early 1900s (Bradby 1997). Sea mullet and yelloweye mullet to supply the bait market dominated finfish catches. The commercial crab fishery did not begin until the late-1950s, with fishers originally targeting blue swimmer crabs using the same gillnets that were used to capture finfish species.

During the late-1970s and early-1980s, a number of changes to the management of the commercial PHE fishery were announced; lists were provided outlining which licence holders were authorised to operate in the fishery and restrictions on the length and mesh size of the fishing nets employed by fishers were introduced. Fishery data from the PHE during this time show an overall decline in fishing effort following these changes. Since 1996, a Voluntary Fishery Adjustment Scheme (VFAS) has resulted in the number of commercial licensees in the fishery being reduced to 11.

In the mid-1990s, the Department allowed fishers in the estuary to trial crab traps (instead of gillnets) to target blue swimmer crabs. Trapping provided many benefits over gillnetting; for example, it was a less time-consuming fishing method, produced less bycatch, reduced the environmental impact from fishing gear and improved catch quality (Bellchambers *et al.* 2005). Fishers were also able to extend their winter fishing season as traps were more effective in winter than gillnets.

By 2000, the majority of blue swimmer crab catch was landed using crab traps. With the reduction in gillnetting in the PHE that resulted from the change to crab traps, haul netting has become the most common method used for targeting sea mullet and other finfish species within the estuary.

3.1.2 Current Commercial Fishing Activities

The commercial fishing sector operating in the PHE is managed as part of the West Coast Estuarine Managed Fishery (WCEMF). The fishery is split into three management areas: Area 1 encompasses the Swan-Canning Estuary in the Perth metropolitan area; Area 2 encompasses the PHE; and Area 3 encompasses the waters of the Hardy Inlet. This document covers Area 2 of the WCEMF, which includes the waters of the PHE, including the Peel Inlet and Harvey Estuary, together with the Murray, Serpentine, Harvey and Dandalup Rivers and all their tributaries and affluents (Figure 3.1).

There are currently 11 licensed fishers in the WCEMF Area 2 who use haul and gillnets to target a mix of temperate estuarine finfish species. In recent years there has been a strong shift to catching fish for human consumption rather than bait, with concomitant improvements in handling and processing, and increases in unit value of the product. Consequently, catches of mullet have declined at times in preference to other, more valuable species. Although the net fishery typically captures around 20 species of finfish each year, sea mullet generally comprises ~ 50 % of the total annual finfish catch in the fishery, with other retained species, such as yelloweye mullet, cobbler, yellowfin whiting (*Sillago schomburgkii*) and Australian herring (*Arripis georgianus*) comprising ~ 40 % of the total annual catch. The majority of catch is taken using haul nets to visually target schools of fish, employing different net lengths and mesh sizes to catch fish of different species or sizes throughout the estuary. Some fishers also set gillnets overnight, particularly when targeting species such as estuarine cobbler (*Cnidogobius macrocephalus*).

Ten of the licence holders in the WCEMF Area 2 are also permitted to retain blue swimmer crabs using crab traps, with a substantial proportion of fishing effort in the estuary directed towards this species. Although permitted to land other species, over 99 % of the total annual trap catch is comprised of blue swimmer crabs. The only other retained species reported in the fishery since 2000/01 has been octopus (*Octopus cf. tetricus*), with generally less than 0.1 t retained annually.

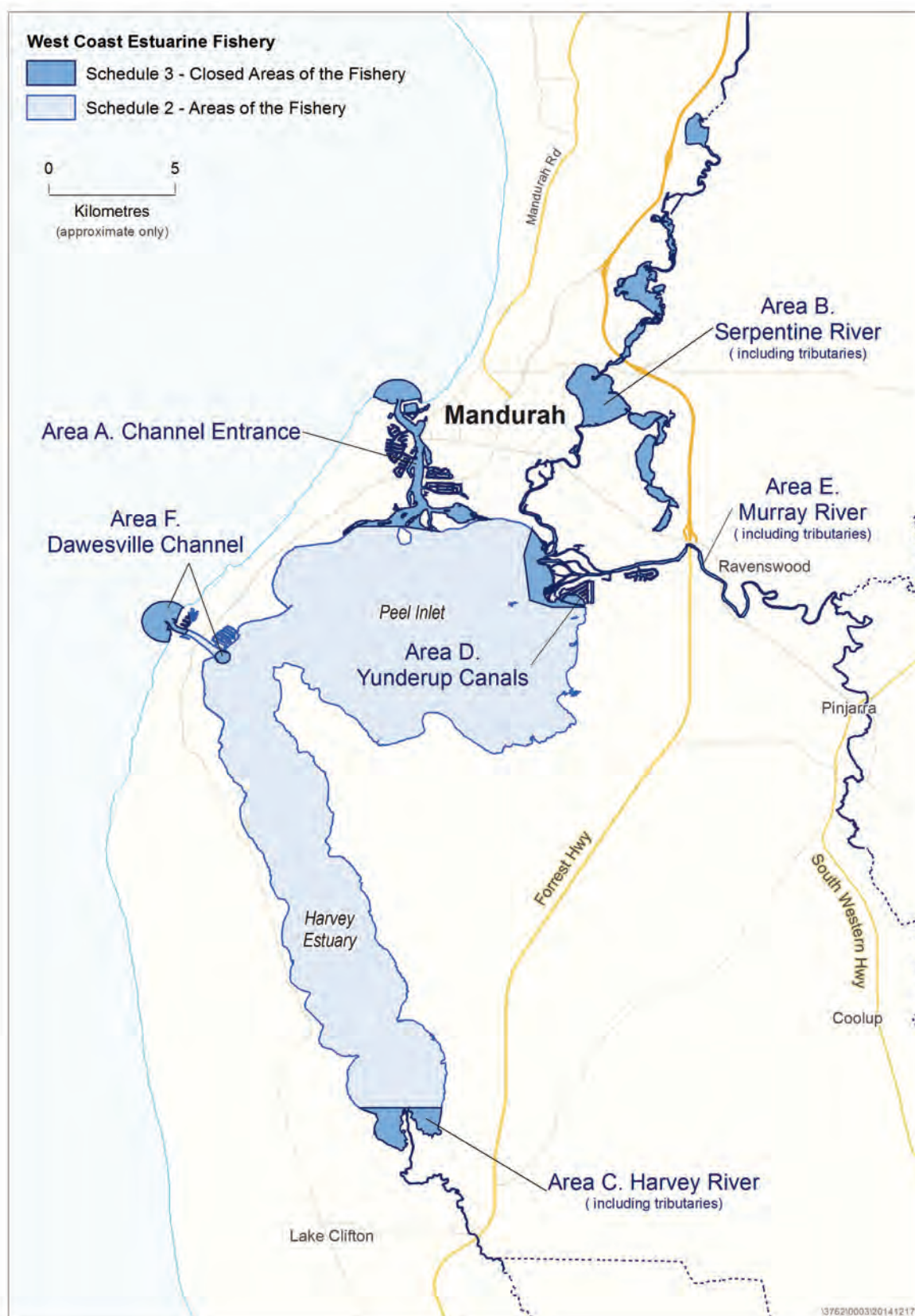


Figure 3.1. The boundaries, extent and closed areas of the West Coast Estuarine Managed Fishery Area 2: the Peel-Harvey Estuary and affluents.

3.1.3 Fishing Gear and Methods

Fishers in the WCEMF Area 2 are permitted to fish by means of a haul net, gill (set) net, beam tide prawn net, hand dip net or crab trap; however, the majority of fishers use haul and gillnets to capture finfish, while blue swimmer crabs are caught by purpose-designed crab traps.

3.1.3.1 Net Fishery

Finfish are primarily targeted using haul and gill nets, with the type of net and mesh size used dependent on the target fish species / size, season and fishing ground (MLFA 2008). Haul and gillnets are typically similar in appearance: flat and rectangular, with a weighted footrope and a float line to maintain an upright position over the sea floor (Figure 3.2). There are specific gear constraints, including mesh size and net length restrictions, in place under the current management arrangements for each net type used (see Section 4.1.3 for more detail).

Although net fishing in the WCEMF Area 2 was historically undertaken from rowboats (Lenanton 1984), now operators set and haul nets using small motorized boats. Owing to regulatory restrictions on commercial boat size (maximum 6.5 m boat length) no mechanised hauling systems are permitted in the fishery (MLFA 2008).

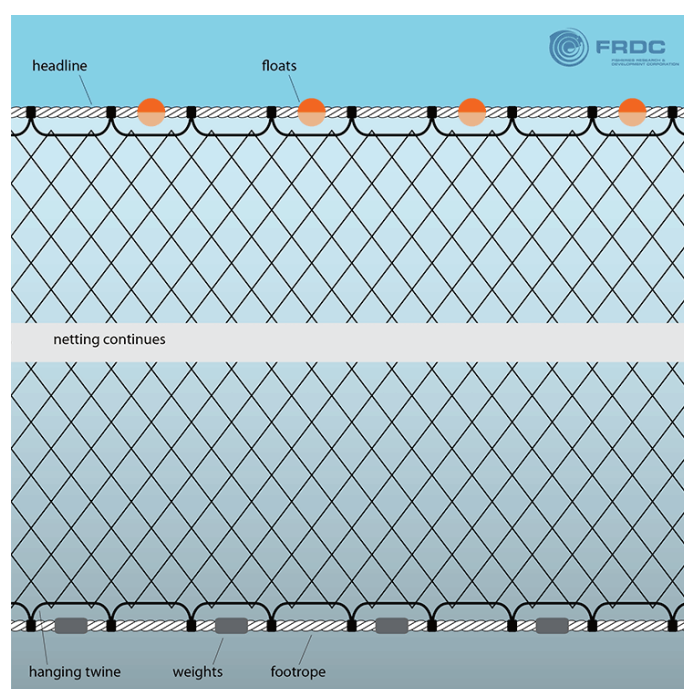


Figure 3.2. Schematic of typical fishing net, such as those used by commercial fishers in the WCEMF Area 2 (Source: Fisheries Research and Development Corporation [FRDC] 2012).

A haul net is used by visually targeting a school of fish, which generally consist of a single species. The net is laid around the school, with one end attached to the boat and the other slowly hauled into the boat. During this process, fish become meshed in the net as the circle gets smaller (Figure 3.3). Mesh sizes may vary along the length of the net in order to allow for more targeted fishing activities (MLFA 2008).

While the net is being drawn from the water, fish are removed and sorted, allowing the immediate release of any unwanted catch (Figure 3.3). The net may also be detached at any time while hand hauling, providing an opening for the release of any unwanted fish (MLFA 2008).



Figure 3.3. Photos of typical haul net fishing activities: (a) setting the net; (b and c) hauling the net by hand; (d) fish caught in mesh; and (e) sample of sea mullet catch. (Photos: K. Travaille [DoF], MFLA 2008).

Gillnets are typically set overnight and left unattended in areas where fish are likely to be caught. Gillnets tend to be used primarily during the winter months owing to the lower abundance of blue swimmer crabs in the estuary during this time. This method is typically used to capture more demersal species, such as cobbler and whiting (MLFA 2008).

3.1.3.2 Trap Fishery

The blue swimmer crab catch in the WCEMF Area 2 is taken by purpose-designed ‘hourglass’ crab traps. There are ten licenced operators in the commercial fishery permitted to use crab traps, with each licensee entitled to 42 traps.

For ease of transport, the hourglass traps are collapsible, with solid stainless metal base and upper rings separated by a central PVC bait pipe. Traps must have an internal volume $\leq 0.31 \text{ m}^3$ or, if the trap is cylindrical, the diameter must be $\leq 1 \text{ m}$. Traps typically have one, two or three pairs of opposing side entry funnels. Mesh size is not legislated, and all fishers use slightly different configurations. The largest mesh used is 3.5 inches and the smallest is two inches. Traps may also be made of two different mesh sizes, with the smaller mesh usually on the bottom half of the trap and the larger mesh on top half. The smaller mesh on the bottom is thought to allow for the crabs to walk up and sit in the upper ring with higher water flow through the larger mesh. This arrangement may also prohibit smaller crabs from walking in the trap through the larger mesh (D. Bell [MLFA], pers. comm., May 2014). All fishers use slightly different gear and are constantly trying new mesh sizes, colours and net grade, i.e. thickness (D. Bell [MLFA], pers. comm., May 2014).

Since 2000, fishers have included voluntary escape gaps in all crab traps (Figure 3.4), with the intention of reducing the catch of undersize and juvenile crabs. This fishery is the only commercial crab fishery in WA with escape gaps in their crab traps.

The crab traps are typically set individually, attached to a surface float clearly branded or stamped with the licensed fishing boat number of the authorized boat from which the crab trap was used. Traps may also be set with a maximum of 10 traps attached to each other by negatively buoyant rope, provided at least one crab trap is attached to a surface float.

Traps can only be pulled once in every 24-hour period (when the fishery is open, noting that all traps are removed from the water during seasonal and weekend closures) and are typically baited with sea mullet and yelloweye mullet from the local net fishery (see Section 9.2.1 for more information on bait usage).

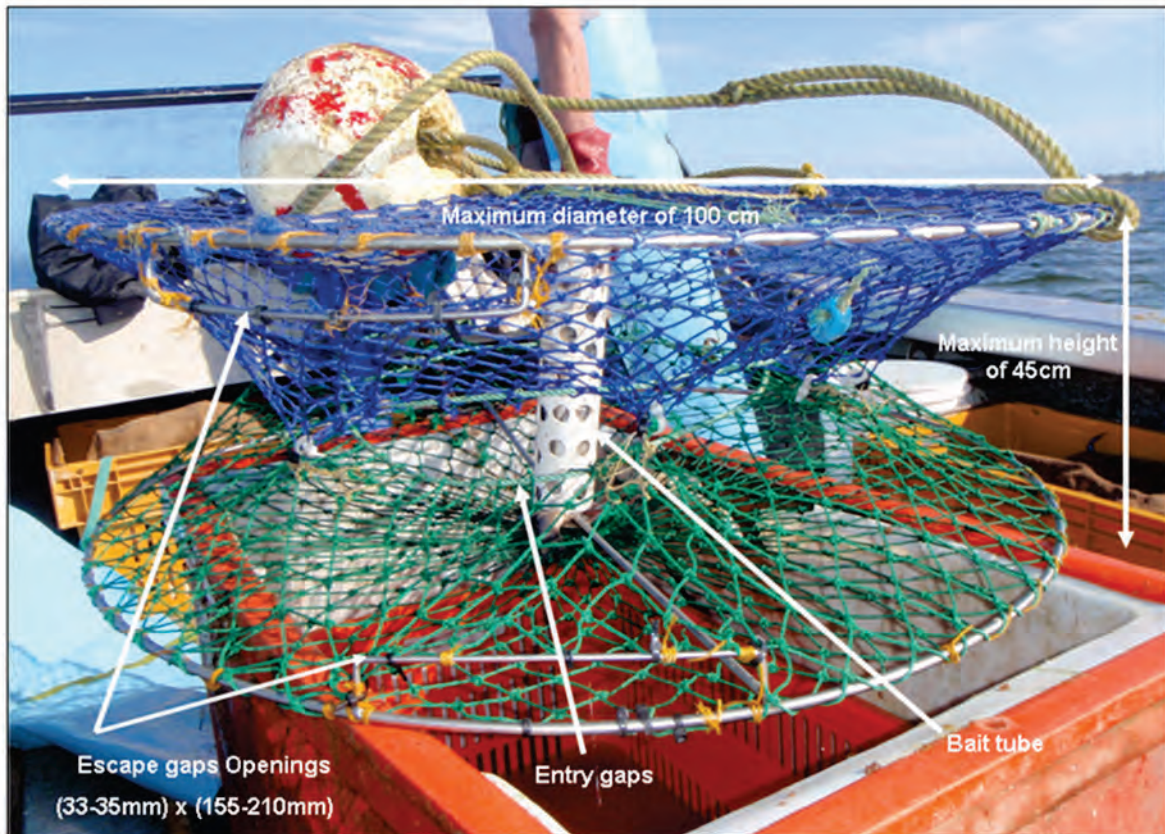


Figure 3.4. Commercial crab trap used in the WCEMF Area 2 showing escape gap

Based on information collected during the commercial monitoring program (see Section 8.4.2.1.2), there are seasonal changes in the spatial patterns of commercial blue swimmer crab fishing within the estuary (Figure 3.5). Fishing during the summer months (November – March) is generally focused on the central regions of the Peel Inlet and Harvey Estuary. During autumn, fishing shifts towards the north-west region of the Peel Inlet and top end of the Harvey Estuary, and by winter, fishing is largely concentrated around the entrance to the Dawesville Channel (Figure 3.5). During spring, there is greater spatial distribution throughout the Harvey and Peel Inlets however, this is most likely an artefact of sampling during the seasonal closure months of September and October (Figure 3.5). Very little fishing activity for blue swimmer crabs occurs in the lower region of the Harvey Inlet and the south-east region of the Peel Inlet, where the water is very shallow.

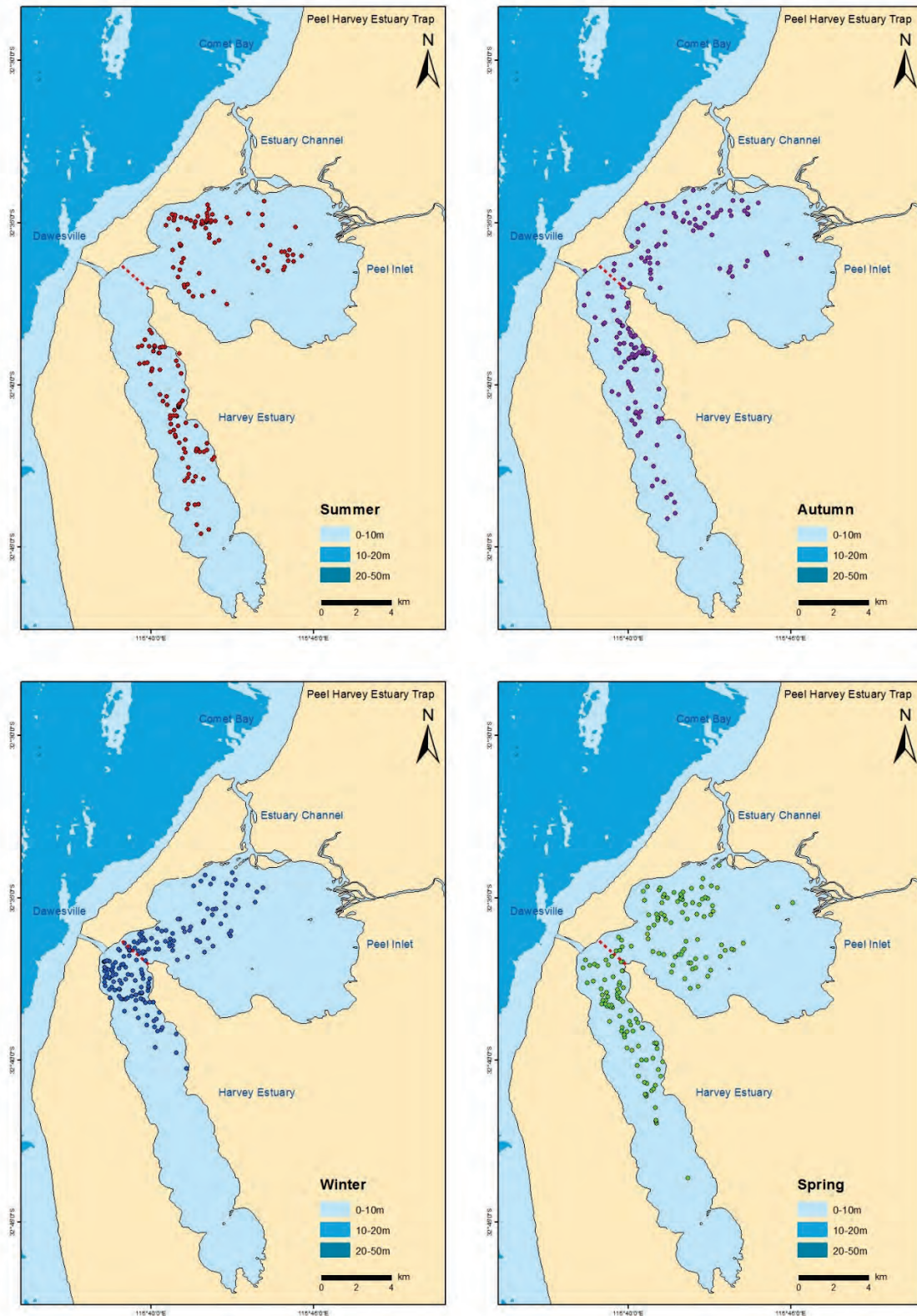


Figure 3.5. Seasonal plots showing start locations of trap lines sampled during commercial catch monitoring surveys aboard commercial vessels in the WCEMF Area 2 between March 2007 and November 2014 inclusive. Seasons are defined as: Summer (Dec – Feb), Autumn (Mar – May), Winter (Jun – Aug) and Spring (Sep – Nov).

3.1.4 Commercial Catch and Effort

3.1.4.1 Sea Mullet

Current nominal netting effort in the WCEMF Area 2 is significantly lower compared to the earlier years of the fishery (Figure 3.6, Figure 3.7) primarily due to a VFAS that has reduced effort levels by removing licences in the fishery. The number of commercial vessels authorised to fish in the PHE has steadily declined from around 50 in the mid-1970s to 11. Since the conversion to using traps for targeting blue swimmer crabs in 2000, the effort targeting finfish in the PHE has remained relatively stable, fluctuating between 600 and 1200 method days per year (Smith *et al.* 2014).

Marked declines in sea mullet catch in the WCEMF Area 2 are evident in the periods 1988-1990 and 1998-2000 (Figure 3.6, Figure 3.7). Both of these declines were associated with effort reductions. Since 2000, sea mullet has been mainly harvested by haul net by commercial fishers using a targeted fishing approach. Total annual catches of sea mullet in the WCEMF Area 2 have fluctuated between ~ 50 and 70 t since 2000.

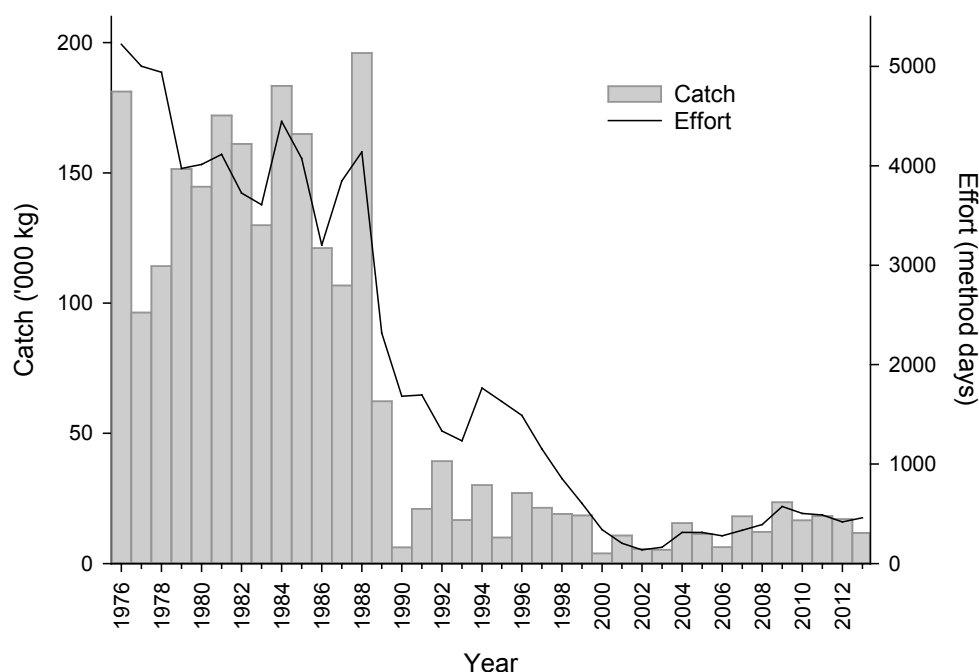


Figure 3.6. Total annual gillnetting effort and annual sea mullet catch by gillnet in the WCEMF Area 2 between 1976 and 2013.

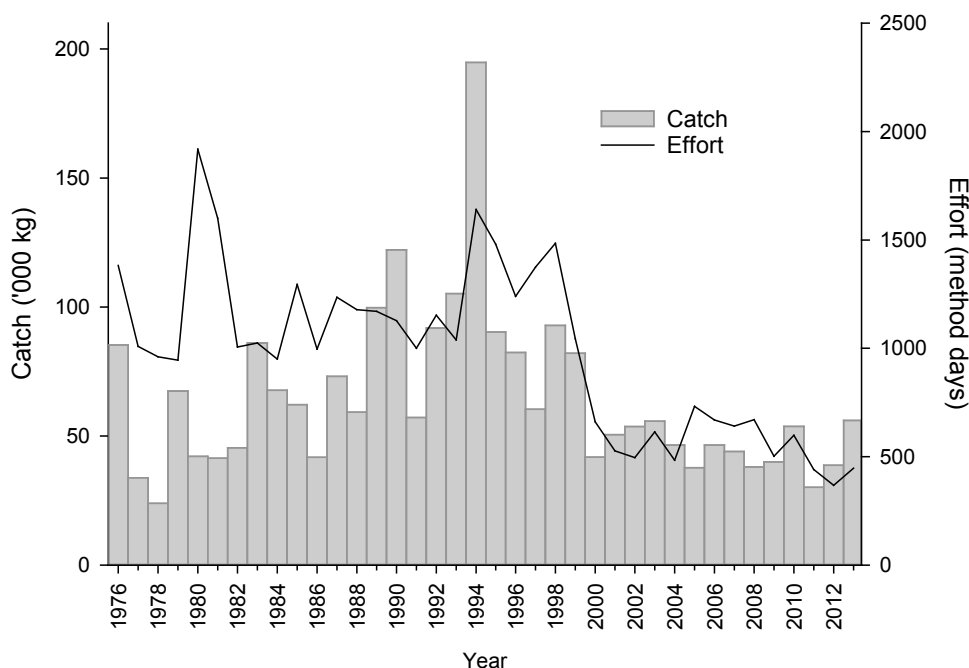


Figure 3.7. Total annual haul netting (includes early records of beach seining and beach hauling) effort and annual sea mullet catch by haul net in the WCEMF Area 2 between 1976 and 2013.

3.1.4.2 Blue Swimmer Crabs

Substantial commercial fishing for blue swimmer crabs in the PHE began in the 1980s, with fishers using gillnets to target blue swimmer crabs primarily over the summer months. Annual catch and effort was highly variable during this time, fluctuating from less than 2 t (from 175 fisher days) in 1981/82 to nearly 75 t (from 1621 fisher days) in 1987/88 (Figure 3.8).

The gradual conversion from gillnets to traps in the mid- to late 1990s resulted in an increase in annual blue swimmer crab catches, largely due to the increased efficiency of the hourglass traps compared to gillnets. Since the beginning of this conversion, annual commercial trap catches of blue swimmer crabs have fluctuated between 11 t (from 358 fisher days) in 1995/96 to a peak of 104 t (from 1657 fisher days) in 2006/07 (Figure 3.8). Trends in nominal catch rate have followed those for catch, with effort remaining relatively stable (Figure 3.9).

The commercial blue swimmer crab catch in 2007/08 dropped 13.5 % from the previous year's catch to 90 t, with a nominal catch rate of 1.45 kg / traplift. This was followed by a significant (49 %) decrease in catch to 48 t for the 2008/09 financial year (Figure 3.8). The mean nominal catch rate for 2008/09 was 0.85 kg / traplift, the equal lowest mean annual catch rate since the conversion from gillnets to crab traps (Figure 3.9; see also Section 8.1.2 for outcomes of the review of available data undertaken at this time).

During 2009/10, catches increased to 64 t with a nominal catch rate of 1.3 kg / traplift. Catches have remained high since this time, with 102 t (1517 fisher days) reported in 2012/13 and the equal highest catch on record of 104 t (1717 fisher days) in 2013/14. The increase in

2012/13 tonnage from proportionally less fisher days indicates an increase in fishing efficiency and / or increase in abundance, with a nominal catch rate of 1.6 kg / traplift. Due to an increased number of fisher days in 2013/14, the catch rate declined slightly to 1.44 kg / traplift (Figure 3.9).

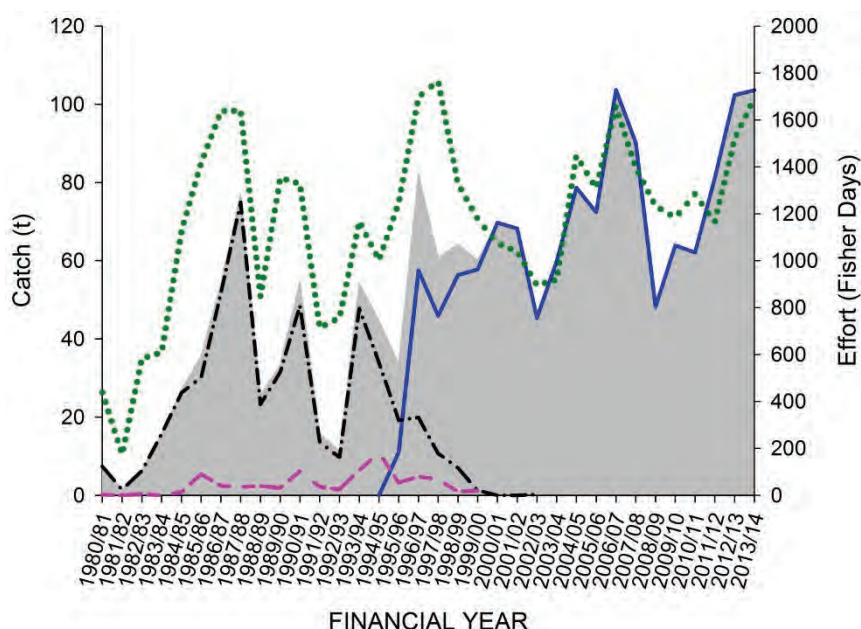


Figure 3.8. Annual commercial blue swimmer crab catch (tonnes, t) in the WCEMF Area 2 by fishing method, and overall effort (fisher days) irrespective of method, from 1980/81 to 2013/14. Total catch (■); crab traps (—); gillnets (—); other methods (---); effort (fisher days) (•••). Annual catch and effort is presented by financial year (1 July – 30 June).

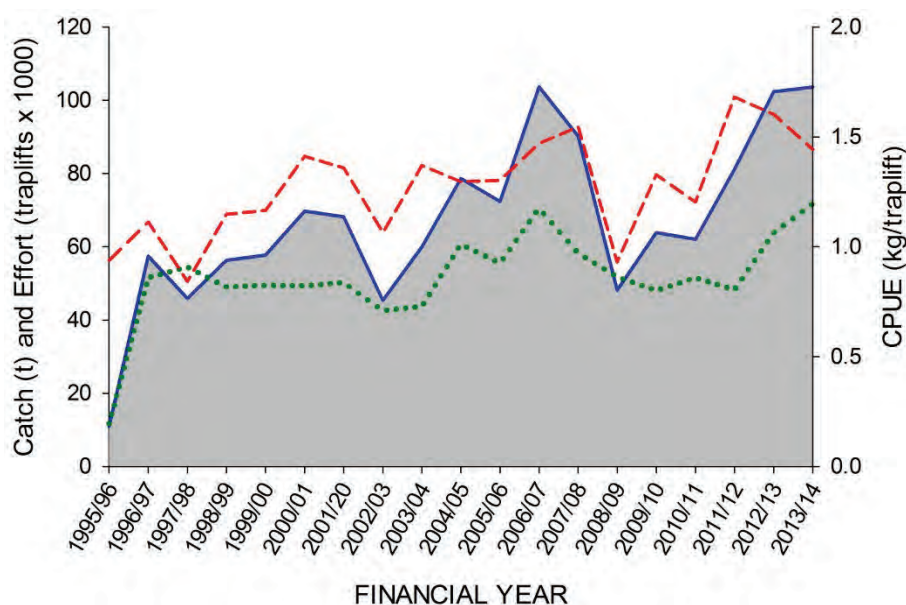


Figure 3.9 Annual commercial blue swimmer crab trap catch (tonnes, t) (■) in the WCEMF Area 2, indicating effort (trap lifts x 1000) (•••) and nominal catch rate (catch per unit effort; CPUE, kg / traplift) (---) between 1995/96 and 2013/14. Data is presented by financial year (1 July – 30 June).

The majority (63 %) of the annual commercial catch of blue swimmer crabs in the WCEMF Area 2 is typically taken during summer months, i.e. December – March. This was particularly the case when blue swimmer crabs were targeted using gillnets (prior to the late-1990s), although there has been an increase in fishing effort during the autumn and winter months since the conversion to crab traps (Figure 3.10). Note that there has been an annual seasonal closure of the fishery from 1 September – 31 October since 2007.

Over 2013/14, trapping effort remained relatively stable, with a slight increase over the summer months. Blue swimmer crab catches in the estuary increased over the summer months, from 5.5 t in November to a peak of 18.9 t by January. Catches remained high through to April (autumn) before dropping to 8.6 t in May. Nominal catch rates followed catch trends with a peak of 2.3 kg / traplift in January (Figure 3.11). There was a significant decline in blue swimmer crab catch and catch rates from March 2014 to a low of 0.7 t and 0.5 kg / traplift in August (Figure 3.11), which coincides with the movement of blue swimmer crabs out of the estuary into oceanic waters to spawn.

Nominal blue swimmer crab catch rates generally follows catch in the WCEMF Area 2, with higher numbers (catch and catch rates) reported over the summer months. Although historically, monthly catch rates have been relatively comparable between years, there has been a marked increase in the monthly catch rates since the 2011/12, with catch rates over the past three years remaining over 2.0 kg / traplift throughout the summer (Figure 3.12). The high summer catch rates corresponds to the influx of crabs recruiting to the fishery during this time.

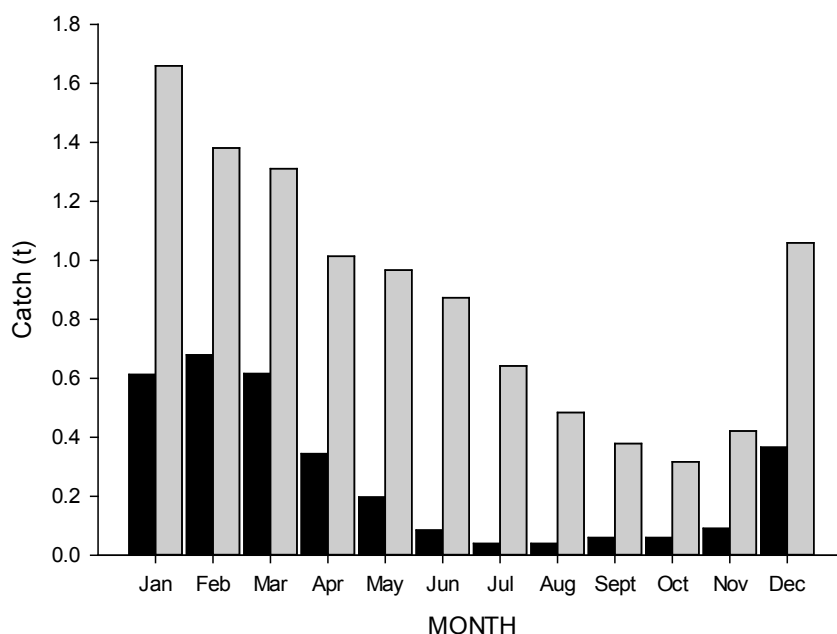


Figure 3.10. Mean monthly commercial blue swimmer crab catch (tonnes, t) from the WCEMF Area 2 using gillnets (■; 1980–1995) and hourglass traps (▒; 1996–2013). Monthly calculations for September and October are based on data prior to 2007 as a seasonal closure was introduced in 2007 that spans these months.

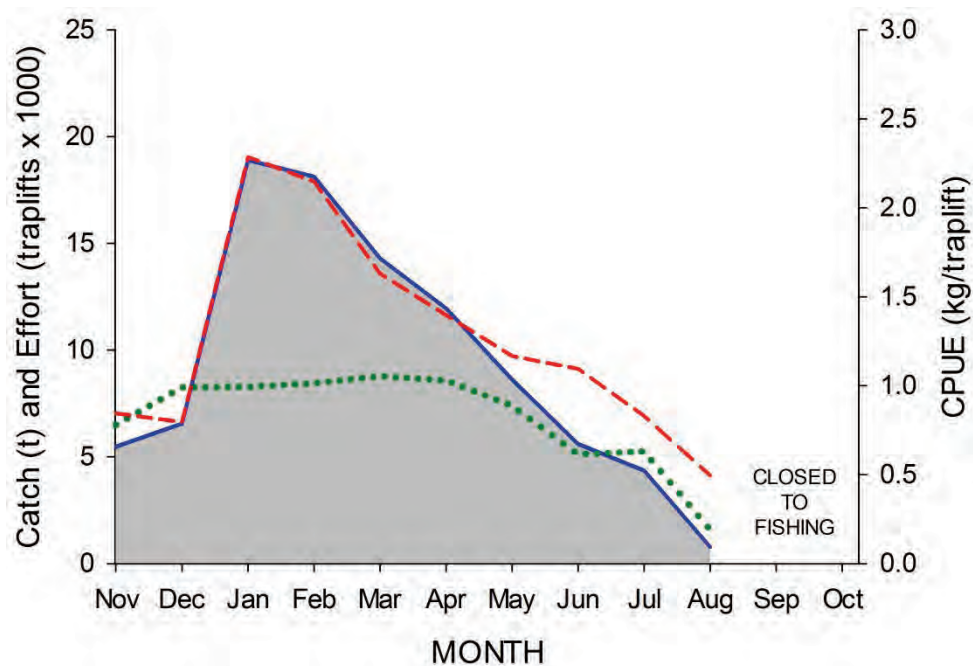


Figure 3.11. Monthly blue swimmer crab catch (tonnes, t) (■), effort (trap lifts x 1000) (●●●) and CPUE (kg / traplift) (---) for the 2013/14 fishing season (1 November – 31 August) in the WCEMF Area 2.

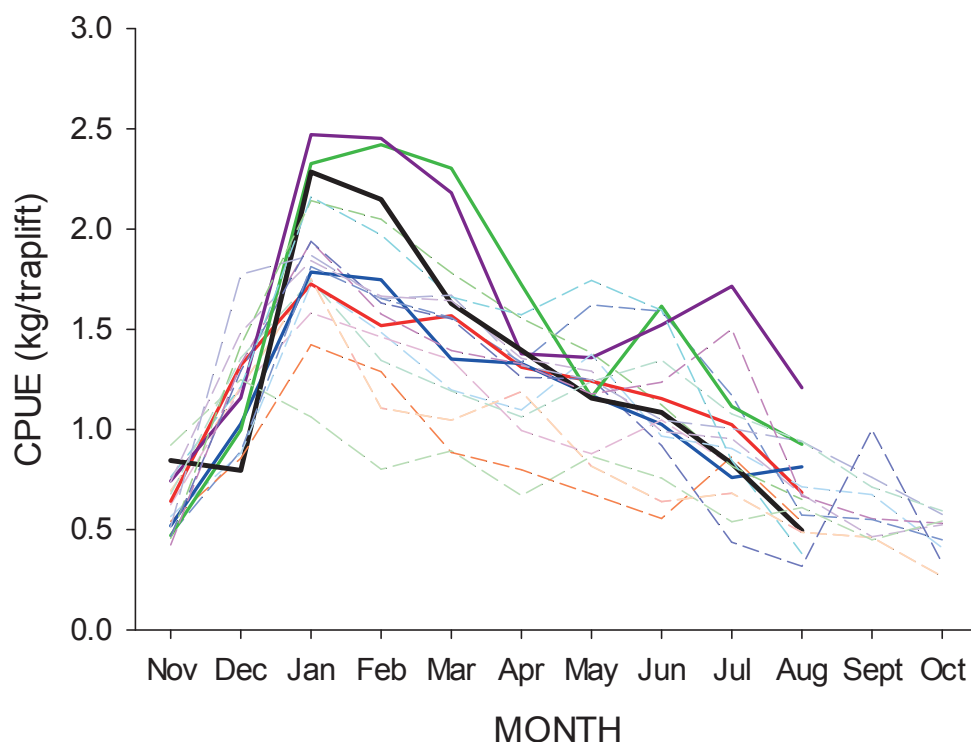


Figure 3.12. Comparison of blue swimmer crab CPUE (kg/traplift) for the 2013 fishing season vs historical data in the WCEMF Area 2. (---) pre-2009/10 season (1995/96-2008/09), (—) 2009/10 season, (—) 2010/11 season, (—) 2011/12 season, (—) 2012/13 season, (—) 2013/14 season.

3.2 Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery

3.2.1 Current Recreational Fishing Activities

Due to its size and proximity to the cities of Mandurah and Perth, the PHE is one of the most popular estuaries for recreational fishing in the south-west of WA. Blue swimmer crabs are the most commonly targeted species by recreational fishers in the PHE, with this region providing much of the State's focus for recreational crabbing (Malseed & Sumner 2001). The majority of recreational fishers in the PHE use baited drop nets (see below for method description) from boats to capture blue swimmer crabs throughout the estuary, although drop nets are also set from bridges, jetties and canal houses. Shore-based fishers primarily use wire scoop nets to capture crabs in shallow water areas of the estuary (Malseed & Sumner 2001).

Crabbing in the PHE has a large cultural and social significance in the local community and represents one of the most popular recreational activities undertaken in the estuary (Department of Conservation and Environment 1985). A charter operator in Mandurah offers regular crabbing tours on the estuary, and visitors to the area often hire a dinghy or houseboat for the day to go crabbing. Each year in March, the Mandurah Crab Fest showcases the PHE, along with the vibrant foreshores, art and cultural precincts of Mandurah. The event attracted more than 130,000 locals and visitors in 2014 (City of Mandurah 2014).

3.2.2 Fishing Gear and Methods

The blue swimmer crab recreational fishery in the PHE comprises fishes crabbing from boats, bridges, jettys, private houses along canals, hire houseboats and along the estuary shore. While boat-based fishers typically use drop nets when fishing for crabs, shore-based fishers use both drop and scoop nets (Lai *et al.* 2014). A small number of fishers also snorkel / free dive for crabs, collecting them by hand. Recreational fishers are also permitted to capture crabs using a hand-held, blunt wire hook, although this method is not often used.

There are 16 major boat ramps within the PHE (eight referred to as the eastern ramps and eight referred to as the western ramps), three popular crab scooping areas and four bridges / jetties in the Mandurah entrance channel that are commonly used by blue swimmer crab recreational fishers (Figure 3.13; Malseed & Sumner 2001; Lai *et al.* 2014).

Recreational crabbing activities occur primarily over the summer and autumn months (December – May) each year, with the greatest activity in January and February (Lai *et al.* 2014). This is the time of year when legal-size crabs are most abundant in the estuary (Potter *et al.* 1983, 1998) and are therefore available for capture.

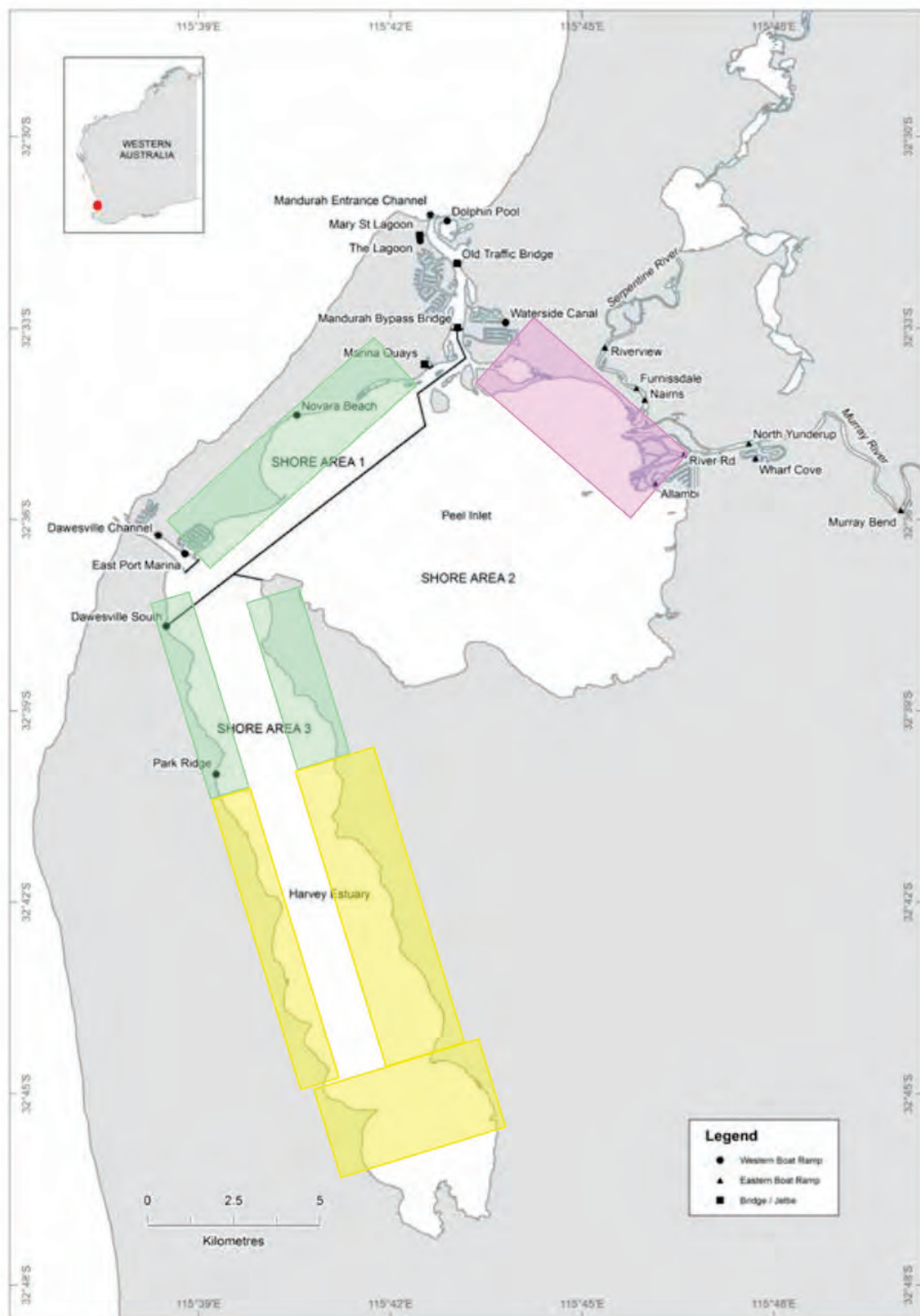


Figure 3.13. Boat ramps and estimated main recreational blue swimmer crab fishing areas of the PHE. Pink shading indicates Coodanup Scooping Area; green shading indicates Peel/Harvey Scooping Area; and yellow shading indicates Harvey Scooping Area (Adapted from Malseed & Sumner 2001 and Lai *et al.* 2014).

3.2.2.1 Drop Nets

Drop nets (Figure 3.14) are commonly used in deeper water (generally 2 – 2.5 m depths) areas of the estuary. They are typically cylindrical in shape with mesh sides and no top (see Figure 3.14) and must be no wider than 1.5 m in diameter (DoF 2014a). The bottom of the drop nets may be made of either the same flexible nylon mesh as the sides or of galvanised wire mesh (Hotbite 2012).

Drop nets are typically baited, with bait holding devices, such as wire clips or plastic bait baskets, attached on the inside of the bottom of the net (Hotbite 2012). The main bait used is sea mullet, chicken and lamb (see Section 9.2.3.1 for more information on bait usage).

When set from a boat, the nets are typically set individually on a single line attached to a float, with fishers setting groups of drop nets a line for easy retrieval. After all the drop nets are set, fishers typically remain near their line for easy retrieval 10 – 15 minutes later (J. Tonkin [DoF], pers. comm., May 2014). There is a maximum limit of 10 drop nets per person or 10 drop nets per boat, regardless of how many people are on board.

Fishers may also set drop nets from bridges and jetties in the entrance channels or from the shore.



Figure 3.14. Wire mesh bottom baited drop net used by boat- and shore-based recreational fishers in the PHE to target blue swimmer crabs (Photo: Alastair Harry [DoF] 2014).

3.2.2.2 Scoop Nets

Scoop nets (Figure 3.15) are bowl-shaped and made of rigid wire mesh not capable of entangling a crab. They are required to have an internal diameter of ≤ 375 mm and a depth of

≤ 210 mm (DoF 2014a). These nets are used in the shallower areas around the shore of the estuary (generally 0 – 1 m depths), predominantly by wading or from a drifting boat, and are not baited.



Figure 3.15. Scoop net used primarily by shore-based recreational fishers in the PHE to target blue swimmer crabs (Photo: Alastair Harry [DoF] 2014).

3.2.3 Blue Swimmer Crab Recreational Catch and Effort

Estimates of boat and shore based blue swimmer crab recreational catches in the PHE are available from two dedicated surveys undertaken in the estuary in 1998/99 and 2007/08 (Malseed & Sumner 2001; Lai *et al.* 2014; see Section 8.4.2.2 for methodology). The first survey estimated the total retained recreational catch of blue swimmer crabs in the PHE for the 12 months from 1 August 1998 to 31 July 1999 was ~ 289 t (Malseed & Sumner 2001), however, the uncertainty is an estimated range of 251 – 377 t (Johnston *et al.* 2014a; Lai *et al.* 2014). The second survey estimated range for the total retained recreational catch of blue swimmer crabs for the 12 months from 1 November 2007 to 31 October 2008 was 107 – 193 t (Johnston *et al.* 2014a). In both these surveys, the majority (~ 70 %) of the blue swimmer crab estimated catch was taken by boat-based fishers, with lower levels of catch from shore-based scoop netters and fishers operating from bridges, jetties, canals and hire house boats. It should be noted, that these estimates from creel surveys do not account for recreational fishing of blue swimmer crabs undertaken outside of daylight hours (Lai *et al.* 2014).

In 2011/12, a state-wide survey of licenced boat-based fishers was undertaken (Ryan *et al.* 2013). This integrated survey included off-site phone surveys, on-site boat ramp surveys and

a remote camera survey to account for the 24-hour nature of recreational fishing. The survey indicated a preliminary estimate of boat-based retained recreational catch of blue swimmer crabs in the PHE was ~ 51 t (Integrated Fisheries Allocation Advisory Committee [IFAAC] in prep.). A second state-wide recreational fishing survey was completed in 2013/14 using this same framework (Ryan *et al.* in prep).

Data from these surveys and from the statutory reporting provided by the commercial fishing sector have been used to determine proposed catch-share allocations to the commercial and recreational fishing sectors as part of a formal Integrated Fisheries Management (IFM) process recently undertaken for the PHE blue swimmer crab resource (see Section 4.4 below).

4. Fishery Management

An overview of the fishery-specific governance and management relating to the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery is presented below. More detailed information, including a description of the long- and short-term management objectives for these fisheries, is provided in the MSC Principle 3 Sections 12 and 13.

4.1 Commercial Management System

The WCEMF Area 2 is managed by the Department under the following legislation, which can be accessed via the Department's website¹:

- *Fish Resources Management Act 1994 (FRMA)*²;
- *Fish Resources Management Regulations 1995 (FRMR)*;
- FRMA Part 6 – *West Coast Estuarine Managed Fishery Management Plan 2014*; and
- FRMA Section 43 Order – *Closed Waters Professional Netting (Rivers, Estuaries, Inlets and Lakes South of 23 ° South Latitude) Notice 1992*.

Fishers must also comply with the requirements of the:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- *Western Australian Marine Act 1982*; and
- *Western Australian Wildlife Conservation Act 1950*.

4.1.1 FRMA

The FRMA provides the overarching legislative framework to implement the management arrangements for the WCEMF Area 2 and contains the head powers to determine a management plan (section 54). WA fisheries management plans are subsidiary legislation which set out the operational rules that control managed commercial fishing activities and should be viewed in conjunction with other specific relevant subsidiary legislation and strategies in place for the WCEMF Area 2. The management plan provides the power (pursuant to section 58) to issue and restrict the number of authorisations and regulate other conditions and grounds relating to fishing. There is also power to set the capacity of the fishery under a management plan (section 59). The FRMA also sets out the procedure for determining and amending a management plan (sections 64 and 65). Under section 43 the Minister may prohibit fishing by order published in the Government Gazette.

4.1.2 FRMR

The FRMR contain a number of requirements pertaining to all commercial fisheries in WA. For example, regulation 64 requires commercial fishers to submit mandatory catch returns in

¹ http://www.fish.wa.gov.au/About-Us/Legislation/Western_Australian_Fisheries_Legislation/Pages/default.aspx

² Note the FRMA will be replaced by *Aquatic Resources Management Bill* once enacted.

the form approved for that fishery, detailing retained species catches, fishing effort, interactions with ETPs and fishing location.

As also prescribed in the FRMR, commercial fishers must comply with a minimum size limit of 127 mm CW for blue swimmer crabs caught in the PHE.

4.1.3 Management Plan

The commercial WCEMF Area 2 is managed under the *West Coast Estuarine Managed Fishery Management Plan 2014*. This formal statutory document provides the framework for the management measures for this fishery, which include:

- **Effort controls:** The maximum number of boats specified on a licence is three; however, only one boat may be used by each licence holder at any one time. All boats used in the fishery are limited to a maximum size of 6.5 m length.

The total capacity of fishing gear in the WCEMF Area 2 is restricted to the following:

- 12 000 m of haul net;
- 12 000 m of set net;
- 96 m of beam-tide prawn net; and
- 420 crab traps.

In addition, an operator must not set, pull or haul more than 1000 m (total combined length) of set and hauls nets in the WCEMF Area 2 at any one time.

- **Gear restrictions:** Operators may only fish using a set net, haul net, beam tide prawn net or a hand dip net.

Haul nets must have a mesh size ≥ 51 mm or:

- A mesh size of ≥ 28 mm but < 44 mm if the net is 55 metres or less in length;
- A mesh size of ≥ 44 mm but < 47 mm if the net is 110 metres in length; or
- A mesh size of ≥ 47 mm but < 51 mm if the net is 500 m or less in length.

Set nets must have a mesh size ≥ 51 mm and ≤ 114 mm. If the mesh size is ≥ 57 mm, the net must have a depth of 50 meshes or less; if the mesh size is < 57 mm, the net must have a depth of 33 meshes or less.

Blue swimmer crabs may only be targeted using traps, which must have an internal volume of ≤ 0.31 m³ or, in the case of a cylindrical trap, have a diameter of ≤ 1 m.

- **Seasonal closure:** There is a seasonal fishing closure for blue swimmer crabs from 1 September to 31 October each year (applies to both the commercial and recreational sectors).
- **Temporal closures:** Specific weekend and daytime closures are in place for both the net and trap commercial fisheries.

- Set and haul nets must not be used between 0800 hours on any Saturday and 0500 hours on the following Monday.
- Crab traps may not be set nor remain in the water:
 - From 1 November to 31 March at any time between 0900 hours on any Saturday and 0330 hours on the following Monday.
 - From 1 April to 31 August at any time between 1000 hours on any Saturday and 0330 hours on the following Monday.
- Daily time restrictions also limit when permit holders fishers can set or retrieve their crab traps. Fishers must not pull a crab trap:
 - At any time before 0330 hours or after 0900 hours from 1 November to 31 March; or
 - At any time before 0330 hours or after 1000 hours from 1 April to 31 August.
- **Spatial closures:** There are a number of closed areas throughout the WCEMF Area 2, including within the channel entrance (Area A), Serpentine River (Area B), Harvey River (Area C), Yunderup Canals (Area D), Murray River (Area E) and the Dawesville Channel (Area F; see Figure 3.1 above).

4.1.4 Notices and Orders

The *Closed Waters Professional Netting (Rivers, Estuaries, Inlets and Lakes South of 23° South Latitude) Notice 1992* prohibits all people, other than specified professional fishermen (such as licensees in the WCEMF Area 2), from taking fish by means of set (gill) net, hauling gill net or throw net in the waters described in this notice.

4.2 Recreational Management System

The Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery is managed by the Department under the following legislation:

- FRMA;
- FRMR; and
- FRMA Section 43 Order – *Prohibition on Fishing for Crabs (Peel Inlet and Harvey Estuary) Order 2007*.

Fishers must also comply with the requirements of:

- The EPBC Act;
- *Western Australian Marine Act 1982*; and
- *Western Australian Wildlife Conservation Act 1950*.

4.2.1 FRMA

The FRMA provides the overarching legislative framework to implement the management arrangements for recreational fishing. The power to regulate recreational fishing is in

section 258 (1)(b), while section 257 (1)(b) provides the power to license recreational fishers. Within WA, recreational fishers are not required to hold a general recreational fishing licence, unless fishing from a powered boat, in which case a Recreational Fishing from Boat Licence (RFBL) is required. Although species-specific licences apply for some species; there is no specific blue swimmer crab licence currently in place.

Fish can be protected from recreational fishing under section 45 (1)(c) of the FRMA. Under section 43 the Minister may prohibit fishing by order published in the Government Gazette.

4.2.2 FRMR

The FRMR outlines the fishing methods by which recreational fishers are permitted to fish for blue swimmer crabs and also outlines the legal (commercial and recreational) size restrictions and (recreational) bag / boat limits in place for many species.

- **Recreational gear / method restrictions:** Recreational fishers are only permitted to catch blue swimmer crabs by hand, wire hook, drop net or scoop net. There is a maximum limit of 10 drop nets per person or 10 drop nets per boat, regardless of how many people are on board.
- **Size, condition and species limits:** Blue swimmer crabs have a minimum size limit of 127 mm CW. All berried or undersize crabs are totally protected and must be returned to the water within five minutes of catching them. All protected crabs caught in drop nets must be released before any more drop nets are pulled.
- **Bag / boat limits:** A daily bag limit of 10 crabs and a daily boat limit of 20 crabs (where two or more people are fishing from the boat) applies to all recreational fishers in the WCB.

4.2.3 Notices and Orders

The *Prohibition on Fishing for Crabs (Peel Inlet and Harvey Estuary) Order 2007* closes the PHE to recreational fishing for blue swimmer crabs from 1 September to 31 October each year.

4.3 Harvest Strategies

Resource-specific harvest strategies for the finfish and blue swimmer crab resources of the PHE outline the long- and short-term fishery-specific management objectives for the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery (see Section 13.2). The harvest strategies also provide a description of the performance indicators used to measure performance against these objectives; reference levels for each performance indicator; and associated control rules, which articulate pre-defined management responses designed to maintain each resource at target levels and achieve the management objectives for the fishery (see Section 8 for more detail).

The harvest strategies are intended to make the decision-making considerations and processes for the management of specified aquatic resources publicly transparent and provide a basis for informed dialogue on management actions with resource users and other stakeholders. They provide guidance for decision-makers, but do not derogate from or limit the exercise of discretion required for independent decision-making under the FRMA by either the Minister

for Fisheries, the Chief Executive Officer (CEO) of the Department of Fisheries or other delegated decision-makers in order to meet the objects of the FRMA.

4.4 Integrated Fisheries Management (IFM)

The Department's IFM policy aims to address how fish resources in WA are shared between competing users within the broad context of Ecologically Sustainable Development (ESD). In 2004, the Minister for Fisheries established the Integrated Fisheries Allocation Advisory Committee (IFAAC) under section 42 of the FRMA to investigate IFM resource allocation issues and make recommendations on optimal resource use. The recommendations generally relate to proportional allocations based on historical catch shares of a resource between fishing sectors (e.g. commercial, recreational and customary).

The blue swimmer crab resource of the lower west coast (including the PHE) is currently being considered by the IFAAC to make recommendations on how future blue swimmer crab catches in this region should be allocated between the commercial and recreational fishing sectors (IFAAC in prep.). Customary fishing will continue to be recognised in accordance with Department's existing customary fishing arrangements (see Section 12.1.3.2). As part of this process, adjusted estimates of the retained catch of blue swimmer crabs from recreational fishing surveys to account for late night and early morning fishing (1998/99 and 2007/08 surveys) and / or shore-based fishing (2011/12 survey; Table 4.1; IFAAC in prep.) have been used with the monthly catch data provided by commercial fishers for the same time periods to provide an indication of the proportions of the total catch of blue swimmer crabs in the PHE that are retained by each sector.

As part of IFM, a total annual allowable harvest level for blue swimmer crabs in the PHE will be set based on historical catches. Each sector will be provided with an acceptable catch range, based on the total allowable harvest level and the proportional catch shares, acknowledging that catches anywhere within the catch range would be unlikely to affect the sustainability of the resource and is therefore considered acceptable. Setting explicit acceptable catch ranges has been identified as the most appropriate way to provide the management flexibility required for such a highly-variable stock.

A formal sectoral allocation process to define and assign long-term sectoral shares of the permitted catch of the finfish resources of the PHE has not yet been undertaken.

Table 4.1. Adjusted estimates of total recreational catch (t) of blue swimmer crabs in the Peel-Harvey Estuary in 1998/99, 2007/08 and 2011/12 (IFAAC in prep.)

Year	Adjusted total catch (t)
1998/99	349
2007/08	165
2011/12	80

4.5 Environmental Management under the Ramsar Convention

The Peel-Yalgorup System was designated as a Ramsar Wetland of International Importance in 1990. The Ramsar wetland covers ~ 26 500 hectares and is comprised of four systems: the

Peel Inlet, Harvey Estuary, the McLarty Lakes and the Yalgorup Lakes. It is one of the destination feeding grounds that migratory birds use after they arrive in Australia during their southern migration.

The area is collaboratively managed by multiple government agencies (national, state-wide and local levels) and community stakeholders who have committed to maintain the ecological character of the listed wetlands by implementing 'wise use' practices and legislation (PHCC 2009). As a signatory of the Ramsar Convention, the Australian Government has responsibilities to maintain listed wetlands. To fulfil these responsibilities, an ecological character description was completed for the Peel-Yalgorup System in 2007. The *Peel-Yalgorup System Ramsar Site Management Plan* (PHCC 2009) was developed as a practical site-specific application of the Ramsar 'wise-use' principles. Hale (2008) outlines a monitoring and evaluation guide that was developed to prioritise and inform management activities and assess the ecological character of the system against management objectives.

4.5.1 Monitoring Programs

The WA Department of Water is responsible for the water quality monitoring program, which has measured changes in water quality since 2001. To address the declining water quality within the catchment (see Section 5.3.1) the Environmental Protection Authority (EPA) developed a Peel-Harvey Water Quality Improvement Plan, which is implemented through the 'Filtering the Nutrient Storm' project. This plan recommends actions to decrease nutrient input to the estuary to reduce algal blooms.

A number of other natural resource management projects have been completed as part of the Ramsar program, including:

- **Waterbird monitoring:** The PHCC has been working closely with Mandurah Bird Observer's Group and Birds Australia (Peel), as well as other community groups, to undertake waterbird monitoring on the Ramsar System. Monitoring of the shorebird population is conducted as part of an Australia wide program i.e. Shorebirds 2020. The 2010 count recorded over 71 000 waterbirds in the Ramsar System.
- **Rehabilitation and Monitoring of Vegetation:** Revegetation and invasive species control programs have been implemented at Lake McLarty and Lake Mealup by the PHCC, the WA Department of Parks and Wildlife (DPaW, previously Department of Environment and Conservation) and local community groups.

5. External Influences

External influences include other factors and activities occurring within the PHE that may or may not impact on the productivity and sustainability of fisheries resources and their ecosystems. The main external influences relevant to the fisheries in the PHE are (1) catches of the targeted stocks by other fisheries, (2) market influences, (3) environmental factors, and (4) urban and other developments.

5.1 Catch from Other Fisheries

5.1.1 Sea Mullet

In addition to the WCEMF Area 2, sea mullet is also commercially targeted, or retained as byproduct, by several other fisheries in the WCB (see Table 5.1 for a catch summary). Between 2009 and 2013, the majority (64 %) of the average sea mullet catch in the WCB was caught in the PHE, with smaller proportions taken by the other fisheries.

Table 5.1. Retained catches (in tonnes, t) of sea mullet by other commercial fisheries in the West Coast Bioregion (WCB) that target the same stock as that in the WCEMF Area 2.

Fishery	Method	Average annual catch (t) 2009 – 2013
West Coast Nearshore Net Fishery (Open Access)	Beach seine, haul net, gillnet	21.7
South West Beach Seine Fishery	Beach seine, haul net	6.0
West Coast (Beach Bait Fish Net) Managed Fishery	Beach seine, haul net	0.9
WCEMF Area 1 (Swan-Canning)	Gillnet, haul net	0.3
WCEMF Area 3 (Hardy Inlet)	Gillnet, haul net	2.8
Cockburn Sound (Fish Net) Managed Fishery + Condition 65 & 66	Beach seine, haul net	0.1
Condition 84 & 19 (Vasse-Wonnerup Estuary)	Gillnet, haul net, beach seine	2.0

Estimates of boat-based recreational catches (e.g. Ryan *et al.* 2013) and reported monthly charter boat catches (DoF unpub. data) of sea mullet in the WCB indicate that boat-based recreational fishers take a very small share of the total landings of this stock.

Some shore-based recreational net fishing occurs in the PHE, with fishers primarily using gillnets to target sea mullet. A Recreational Net Fishing Licence (RNFL) has been required for all recreational net fishing using set (gill), haul or throw nets since 1992. Specific management measures for recreational fishing (in general) and netting in WA, including rules for setting and pulling nets, and closed areas within the PHE, can be found in the *State-wide Recreational Fishing Guide* (DoF 2014a) and the *Recreational Net Fishing Guide* (DoF 2014b).

No estimates of recreational net catches of finfish in the PHE are currently available. However, they are considered to be minor compared to the annual finfish catch landed by the commercial fishing sector.

5.1.2 Blue Swimmer Crabs

In addition, to the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery, blue swimmer crabs are also commercially targeted or retained as byproduct by several other fisheries in south-western WA. The catches are summarised in Table 5.2.

Table 5.2. Retained catches (in tonnes, t) of blue swimmer crabs by other commercial fisheries in south-western WA that target the same stock as that in the WCEMF Area 2.

Fishery	Method	Average annual catch (t) 2009/10 – 2013/14
Warnbro Sound Crab Managed Fishery	Trap	25.9
Mandurah to Bunbury Developing Crab Fishery	Trap	14.5
WCEMF Area 3 – Hardy Inlet	Haul net, trap	0.4
South West Trawl Managed Fishery (Comet Bay)*	Demersal trawl	1.8

*Note that the commercial trawl fisher authorised to catch blue swimmer crabs in Comet Bay by demersal trawling is no longer operating. The licence was bought back by the Department in early 2014.

5.2 Market Influences

During the 1970s and early 1980s, large quantities of sea mullet were sold as bait, primarily for the Western Rock Lobster Managed Fishery. In recent years, sea mullet is primarily sold in smaller quantities for human consumption. A smaller portion of the catch is used as bait by those fishers in the WCEMF Area 2 who are also licenced to catch blue swimmer crabs in the estuary. This market shift and change in demand has substantially influenced catches of sea mullet in the WCEMF Area 2, which are lower than historical levels.

5.3 Environmental Influences

5.3.1 Eutrophication

Approximately 75 % of the catchment area of the PHE has been cleared of natural vegetation for agricultural purposes. Due to the natural low-nutrient levels of the catchment soil, fertilisers have been used to improve agriculture in the area throughout the past century. A large portion of these nutrients have been flushed into the estuary, causing extensive macrophyte growth and toxic algal blooms in the 1960 – 1970s (Fretzer 2011).

Due to eutrophication, the condition of the estuary became a public concern and an extensive study of the estuary was initiated in the late-1970s. This study investigated various aspects of the ecosystem, including nutrient inputs, features of the catchment (e.g. physical features, rainfall and runoff), physical and biological characteristics and hydrodynamics of the estuary and production and abundance of *Cladophora* (Hodgkin *et al.* 1981).

5.3.1.1 The Dawesville Channel

To increase flushing and reduce nutrient levels in the PHE, an artificial entrance channel (the Dawesville Channel) was opened in 1994. The channel was expected to increase salinity in the estuary, making conditions unsuitable for the toxic phytoplankton species *Nodularia*. The channel delivered the predicted increase in water quality, with a reduction in primary production. The channel also benefited seagrass within the estuary due to the less variable salinity regime, maintenance of bottom marine salinities for extended periods and improved water clarity. Macroalgae biomass in the Peel Inlet was significantly lowered, with a change in growth and distribution with peak biomass currently occurring in spring (as opposed to autumn).

The Dawesville Channel had a significant impact on the fish and invertebrate communities within the estuary. The impact of the channel on western king prawns, blue swimmer crabs and other commercially-fished species was investigated by Potter *et al.* (1998). Relevant biological data were collected for these species in 1995 – 1998 and were compared with historical data collected for the same sampling sites in 1979 – 1988 (i.e. prior to the Dawesville Channel). Results indicated that blue swimmer crabs and western king prawns were more abundant and present for longer periods in the Harvey Estuary than prior to the channel. This increase was attributed to:

1. A direct connection between the sea and the Harvey Estuary, which is a shorter distance to travel from the ocean into the Harvey Estuary;
2. A greater tidal water flow into the Harvey Estuary providing a more effective means of transportation into this part of the system; and
3. Salinities in the Harvey Estuary remaining higher for longer periods, providing an environment conducive to the retention of blue swimmer crabs and western king prawns for protracted periods.

The increased tidal movement through the PHE also accounted for the following:

- Small juvenile blue swimmer crabs recruiting from the ocean into the PHE over a longer period of time;
- Female blue swimmer crabs emigrating from the estuary earlier once ovigerous; and
- Prawns often emigrating from the estuary at a smaller size.

Furthermore, the growth of blue swimmer crabs in the estuary became more rapid since the opening of the channel, which has resulted in an earlier attainment of sexual maturity (Potter *et al.* 1998).

Prior to the construction of the Dawesville Channel, the composition of the fish communities in the different basin regions of the PHE differed and did not change markedly throughout the year. Since the opening of the channel, the composition of the fish communities in the different regions have become more similar. They also undergo pronounced seasonal cyclical changes, presumably related to the increased strength of environmental cues that are provided by the exchange in water during each tidal cycle. The number and overall abundance of fish

species in the Harvey Estuary, particularly the southern region, were found to be greater than prior to the opening of the channel. However, there was evidence that the levels of recruitment of the juveniles of each of the main commercial fish species (i.e. sea mullet, yelloweye mullet, cobbler, King George whiting and yellowfin whiting) into the PHE was lower than prior to the construction of the Dawesville Channel. This decline may be due to the reduction in the volume of macroalgae in the estuary resulting in reduced food and areas of protection from predation (Potter *et al.* 1998).

A quantitative model using Ecopath with Ecosim and Ecospace has been applied to the PHE to identify the ecosystem impacts of the artificial entrance channel (Fretzer 2011). Two Ecopath models were developed for PHE consisting of 30 living functional groups, comprised of dolphins, sharks, waterbirds, teleost fish, invertebrates and primary producers, and describing the ecosystem before and after the opening of the Dawesville Channel. The ecosystem of the PHE was found to have declined drastically in total biomass since the opening of the channel, as well as declined in biomass at each trophic level and in the size of flows between the functional groups. Changes in flows and transfer efficiencies illustrate a change in the functioning of the ecosystem since the opening of the Dawesville Channel (Fretzer 2011).

The results of the Ecopath models indicate that the Dawesville Channel has markedly impacted species composition and dominance in floral and faunal communities. Estuarine fish species have decreased, and marine species have become more dominant in the estuary (Fretzer 2011). Ecosim was applied to the model to identify the impact of primary producers on functional groups of the estuary and the impacts of fishing on target and non-target species. Results indicate that primary producers, such as seagrass, have an influence on blue swimmer crab biomass (Figure 5.1). Furthermore, with high nutrient concentrations still present in the PHE from continued agricultural and urban runoff, phytoplankton blooms may potentially reduce the biomass of some fish species, such as sea mullet and yelloweye mullet (Figure 5.2), whereas others, such as Australian herring, may increase in biomass (Fretzer 2011).

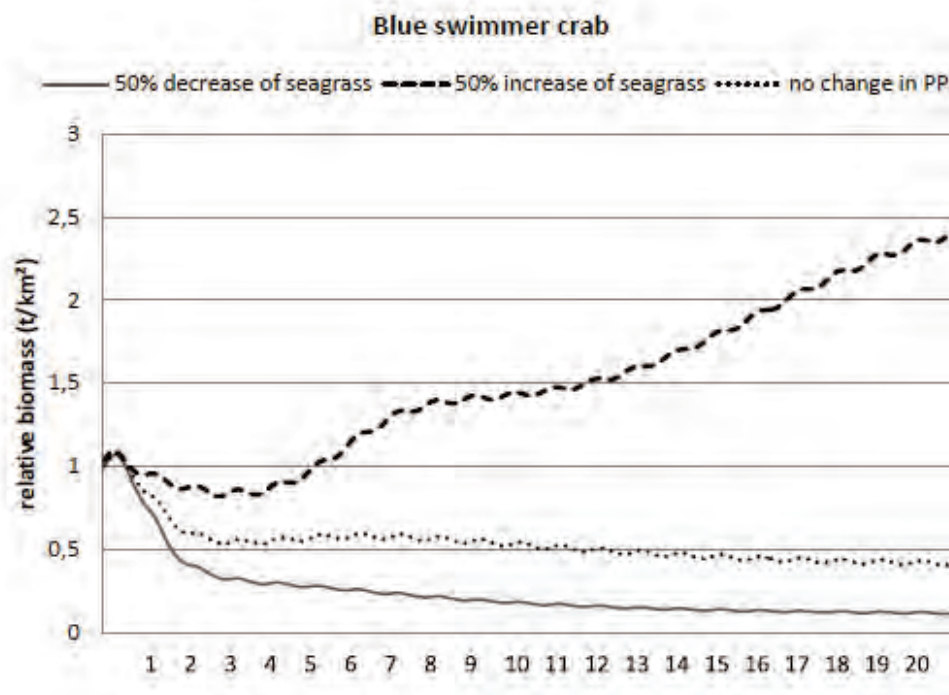


Figure 5.1. Effect of 50 % increase and decrease of seagrass biomass on the relative biomass of blue swimmer crabs in the PHE (Source: Fretzer 2011).

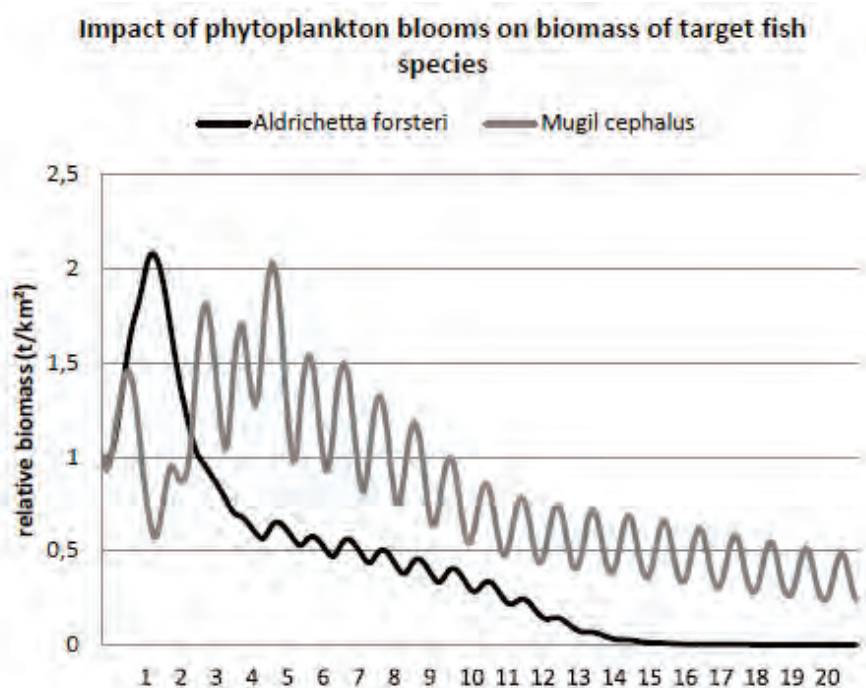


Figure 5.2. Effect of phytoplankton blooms, simulating an increase in biomass of microscopic algae by factor 10, on the target fish species yelloweye mullet (*Aldrichetta forsteri*) and sea mullet (*Mugil cephalus*) in the PHE (Source: Fretzer 2011).

5.3.2 Climate Change

Climate change has the potential to influence different aspects of the biology of species such as sea mullet and blue swimmer crabs. Increased water temperatures as well as changes to

seasonal rainfall patterns and the strength of oceanic currents could all potentially affect migration patterns, spawning success and recruitment of these species in south-western WA.

Changes to the strength of the Leeuwin Current that flows southwards and eastwards along the south-west corner of WA could influence the northward spawning migrations of sea mullet during the spawning season. Increased water temperatures may also lead to shifts in the distribution of sea mullet along the coast, which has been observed for several other finfish species in waters off south-western Australia (Smith *et al.* 2014).

The effects of climate change on blue swimmer crabs are likely to vary between fisheries in WA, based on the large latitudinal and longitudinal range of this species, and depending on the particular ecosystem the crabs inhabit. Long-term climate change predictions for the west coast of WA indicate that rainfall will decrease over time, potentially increasing hypersaline areas in coastal waters and shallow estuaries. Such a rise in hypersalinity may lead to increased mortality of juveniles and adults as blue swimmer crabs do not tolerate high levels of salinity. Declining rainfall could also negatively influence the movement of crabs out of the PHE to spawn, which normally occurs at the onset of winter rains flushing the crabs out of the estuary (Section 2.2.3.1).

The waters of the lower west coast of WA are at the southern extreme of the temperature tolerance of blue swimmer crabs and thus they are highly susceptible to fluctuations in temperature. Johnston *et al.* (2011a) reported cooler than average water temperature in August and September for four consecutive years in Cockburn Sound, which lead to poor spawning success in the subsequent spawning seasons. This was suggested as a major contributing factor in the decline of this fishery and thus needs to be evaluated in future management of blue swimmer crab fisheries in the south-west of WA.

5.3.3 Introduced Pests

The introduction and spread of marine pests in WA waters poses a serious threat to native biodiversity and can have widespread effects on both our economy and health. For example, the Asian paddle crab (*Charybdis japonica*) has the potential to outcompete native species such as the blue swimmer crab if it becomes established in Australia. The Department's Marine Biosecurity Research and Monitoring group continue to implement a series of biosecurity-related projects to ensure early detection of the presence of introduced marine pests in the WCB (Fletcher & Santoro 2014).

Early detection of introduced marine pests is vital if any attempt at eradication or other management strategies is to be successful. When an Asian paddle crab was recently handed in to the Department's Mandurah office without details of where it was captured, 100 traps were deployed in the PHE for several days but no further paddle crabs were found.

5.4 Urban and Other Developments

Significant growth is projected for the Perth and Peel regions over the coming decades. Recent projections have estimated that by 2026 the State's population will grow to ~ 3 million, with the Perth and Peel region projected to be ~ 2.3 million. In light of these

projections, in 2011 the WA Ministers for Planning and Environment and the Commonwealth Minister for the Environment agreed to undertake a Strategic Assessment of the Perth and Peel regions of WA. The Strategic Assessment³ is being led by the Department of the Premier and Cabinet, in partnership with the Commonwealth Department of the Environment (DotE). At a State level, the Department of the Premier and Cabinet is working on the Strategic Assessment with DPaW, the Department of Planning and the Office of the Environmental Protection Authority. The purpose of the Strategic Assessment is to:

- Reduce the need for project-by-project assessment under the EPBC Act in the Perth and Peel region;
- Deliver an effective long-term and strategic response to key environmental issues in the Perth and Peel region, e.g. water quality in the PHE;
- Provide greater certainty to industry on areas that be developed and associated mitigation, including environmental offsets; and
- Provide greater certainty in terms of long-term land supply to meet the needs of a city of 3.5 million people.

5.4.1 Point Grey Development

Recently, the development of Point Grey, a peninsula which separates the Peel Inlet from the Harvey Estuary (Figure 5.3), has been approved by the Commonwealth DotE. The Point Grey Development will include an urban zone for residential purposes, as well as a regional-level marina and associated facilities. The proposed marina is located on the western edge of the Point Grey peninsula, an area historically used for grazing. The proposal also includes the construction of a 2.5 km navigation channel across the Harvey Estuary from the marina to the Dawesville Channel, effectively linking the marina to the Indian Ocean (EPA 2011).

The marina waterbody will occupy 9.8 ha and will be excavated to a maximum depth of 3 m. Excavation of the marina is expected to result in the generation of approximately 660 000 m³ of spoil, which will be used as fill within the Point Grey development and in the construction of two protective groynes adjacent to the entrance channel. The marina will accommodate up to approximately 300 boat pens and will be designed to accommodate boats of maximum length 15 m and draft 1.5 m. Access to the marina water body from the Harvey Estuary will be via a 100 m long and 120 m wide entry channel through the foreshore. Approximately 5.1 ha of foreshore will accommodate car parking requirements for 200 cars and four boat ramps. This area will include a portion of landscaped foreshore between the car park and the shoreline which will contain paths and public toilets, allowing the public to access and use the beach to the west of the marina (EPA 2011).

The potential impacts on the environment are ongoing operational impacts to estuarine water quality and sedimentation of the navigation channel. In addition, the proposal is considered to have localised and temporary direct impacts on estuarine fauna. Based on these issues, a number of recommendations and conditions have been imposed by the EPA (EPA 2011).

³ More information on the Strategic Assessment is available at:
<http://www.dpc.wa.gov.au/Consultation/StrategicAssessment/Pages/Default.aspx>.



Figure 5.3. Location of the proposed Point Grey Development and Marina (Source: EPA 2011).

MSC Principle 1

MSC Principle 1 (P1) focuses on maintaining, indefinitely, fishing activity at a level that is sustainable for the targeted populations (MSC 2013).

6. Stock Status

The status of the sea mullet and blue swimmer crab stocks targeted by fishers in the PHE is assessed annually using a weight-of-evidence approach that considers all available information about the stocks (see Wise *et al.* 2007 for explanation of weight-of-evidence approach). This assessment approach, which is described in more detail in Section 7, is primarily based on evaluating standardised commercial catch rates (primary performance indicator, considered to represent a proxy for overall stock abundance) and catches (secondary performance indicator) in the WCEMF Area 2 relative to reference points calculated based on a reference period in which these indicators have been stable (Section 8.2). In the absence of direct estimates of total biomass for the targeted stocks of sea mullet and blue swimmer crabs, as a precautionary approach, a risk assessment including both species was been undertaken using Productivity Susceptibility Analysis (PSA) methodology (see Section 7.1).

6.1 Current Stock Status

6.1.1 Sea Mullet

As sea mullet matures at 3 – 4 years and is capable of undertaking significant movements during its life cycle between estuarine and nearshore environments (Section 2.1). Therefore, it is considered to be relatively resilient to fishing pressure. A risk assessment undertaken in 2014, which considered the productivity of sea mullet and its susceptibility to each of the fisheries that target the overall managed stock of this species in the WCB (see Section 2.1.2) concluded that the overall risk of significant impacts of fishing on the stock is low (Section 7.1.2.3).

More than 60 % of the total commercial catch of sea mullet in the WCB is landed by the WCEMF Area 2, with recreational catches of this species considered minor compared to those taken by the commercial sector. As sea mullet do not spawn within the PHE, some natural protection is provided to the breeding stock of this species from exploitation by the WCEMF Area 2 during spawning periods. Although other fisheries are able to target the same stocks in oceanic waters outside the estuary, the catches are less than those taken in the PHE (see Section 5.1.1).

The current level of sea mullet catch in the WCEMF Area 2 is lower than historical levels, primarily due to reductions in fishing effort associated with licence buy-backs and changes in markets and demand (Section 5.2) that have substantially changed the way the net fishery in the PHE operates. Since 2000, annual catches of sea mullet by the WCEMF Area 2 have ranged between 46 and 70 t, compared to a historical (1976 – 1999) average of 136 t per year.

Since the start of the reference period for sea mullet (2000 – 2011), the standardised annual catch rate of this species in the WCEMF Area 2 has remained within the target range of 2.2 – 4.6 kg / 100 m netting hour for all years except in 2013, when the indicator measured 6.2 kg / 100 m netting hour (Figure 6.1). Although this shows a substantial increase from previous years, it should be noted that the 95 % confidence interval around this estimate is relatively large (4.2 – 9.0 kg / 100 m netting hour (see also Section 7.1.2.2 on catch rate analysis). Taking into account this uncertainty, the standardised catch rate is still well above the limit reference level of 1.6 kg / 100 m netting hour. The level of sea mullet catch in the WCEMF Area 2 in 2012 and 2013 (56 and 68 t, respectively) is also within the target range (i.e. between the lower and upper threshold levels) of 46 – 70 t (Figure 6.2).

The above information provides evidence that the sea mullet stock is currently exploited at a level below the maximum sustainable yield (MSY), i.e. the stock is highly likely to be above the point at which recruitment may be impaired.

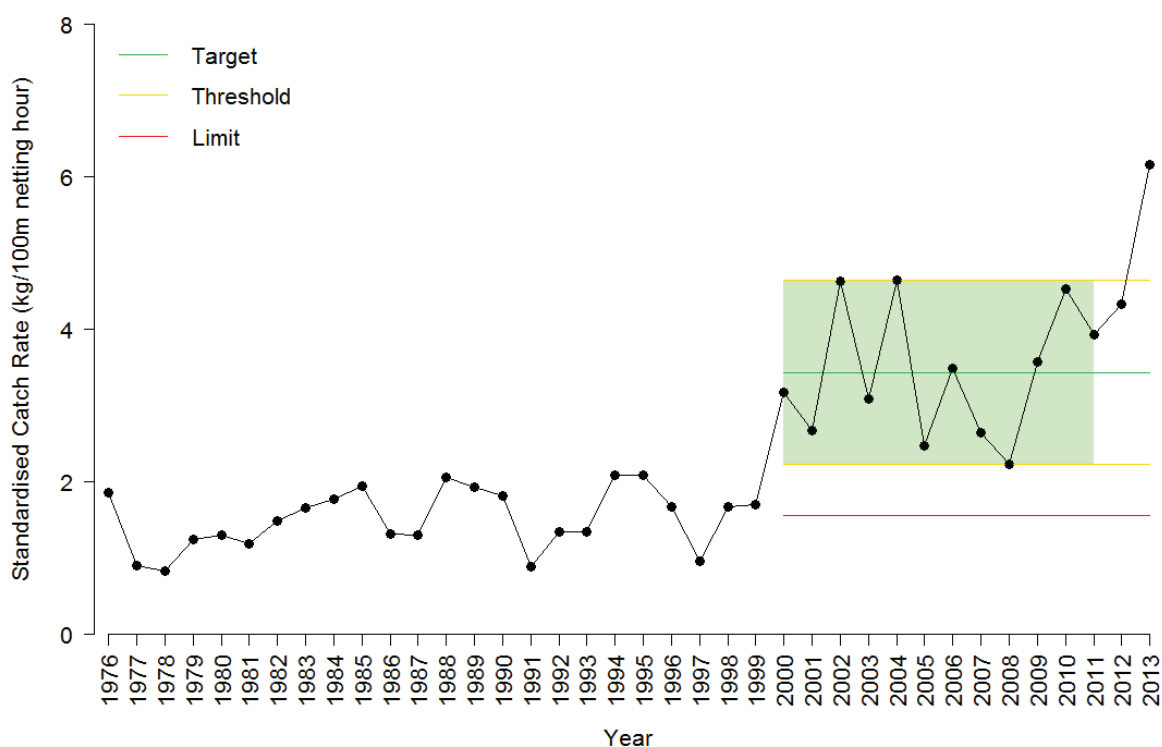


Figure 6.1. Annual standardised commercial catch rate (kg / 100 m netting hour) of sea mullet in the WCEMF Area 2 relative to the associated reference points. The shaded green area reflects the reference period (2000 – 2011), from which reference points have been calculated.

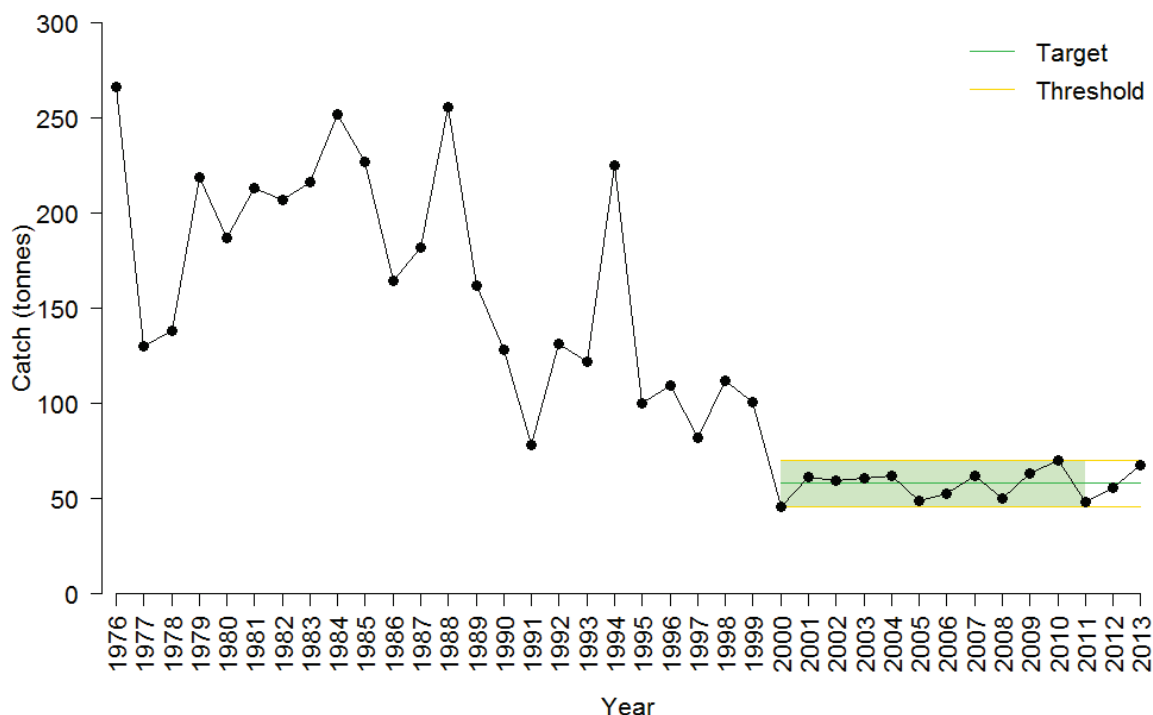


Figure 6.2. Annual commercial catch (tonnes) of sea mullet in the WCEMF Area 2 relative to the associated reference points. The shaded green area reflects the reference period (2000 – 2011), from which reference points have been calculated.

6.1.2 Blue Swimmer Crab

Blue swimmer crab is a highly fecund species with a short life span (Section 2.2) and is therefore generally considered to have a low inherent vulnerability to fishing. A 2014 risk assessment, which considered the productivity of blue swimmer crabs and its susceptibility to each of the fisheries targeting the overall stock of this species in south-west WA, determined the risk to the stock as low (see Section 7.1.3.4). However, as recruitment of this species can be significantly influenced by changes in environmental conditions (Section 2.2.3.4), blue swimmer crab catches can fluctuate between years as a consequence of impacts on the stock that may not necessarily be related to fishing pressure.

The WCEMF Area 2 is currently the largest commercial fishery targeting the stock of blue swimmer crabs in south-west WA in terms of both tonnage and fishing effort (see Section 2.2.2), significant catches are also retained by recreational fishers (Section 3.2.3). Commercial catches of blue swimmer crabs in the PHE have fluctuated at between 45 and 104 t since fishers converted using traps for targeting this species in 2000.

Since 2000/01, annual (by fishing season; 1 November – 31 October) standardised commercial catch rate of blue swimmer crabs in the WCEMF Area 2 has fluctuated within the target range of 0.7 – 1.4 kg / traplift, but has generally remained above 1 kg / traplift. The standardised trap catch rate for the 2013/14 fishing season was 1.14 kg / traplift, which is well above the limit level of 0.5 kg / traplift (Figure 6.3). Annual catches of blue swimmer crabs in the WCEMF Area 2 have remained high in recent years, with a total retained catch in the 2013/14 financial year of 104 t (from 1717 fisher days), which is equal to the upper catch

threshold for this fishery (Figure 6.4). Although total catch has fluctuated, primarily due to environmental influences, the stable time series of annual standardised trap catch rates of blue swimmer crabs in the fishery since the time of this conversion provides evidence that the current level of exploitation of the stock can be sustained and is below MSY.

In response to the standardised catch rate being just above the upper threshold level in 2012/13 (Figure 6.3), data from commercial monitoring and fishery-independent research sampling (Section 8.4.2.1.2 and 8.4.2.3.2) have been examined (see Appendix A for a summary of these data). Comparisons between current and historical commercial monitoring and fishery-independent data sets provide further support that blue swimmer crab stock abundance has been relatively stable over the past decade, with natural protection of the spawning stock occurring due to their exit out of the estuary over winter to spawn in oceanic waters where fishing effort is currently low. The observed increase in the proportion of pre-spawned females in the catches of crabs over the past few years in the PHE (Appendix A), will continue to be closely monitored, along with the level of fishing effort in the oceanic waters, to ensure that fishing pressure does not compromise the breeding stock. Long-term climate changes such as declining rainfall could significantly influence the movement patterns of crabs in the PHE (Section 5.3.2), which may result in more mated, pre-spawned females remaining inside the estuary and being available for capture during the winter months.

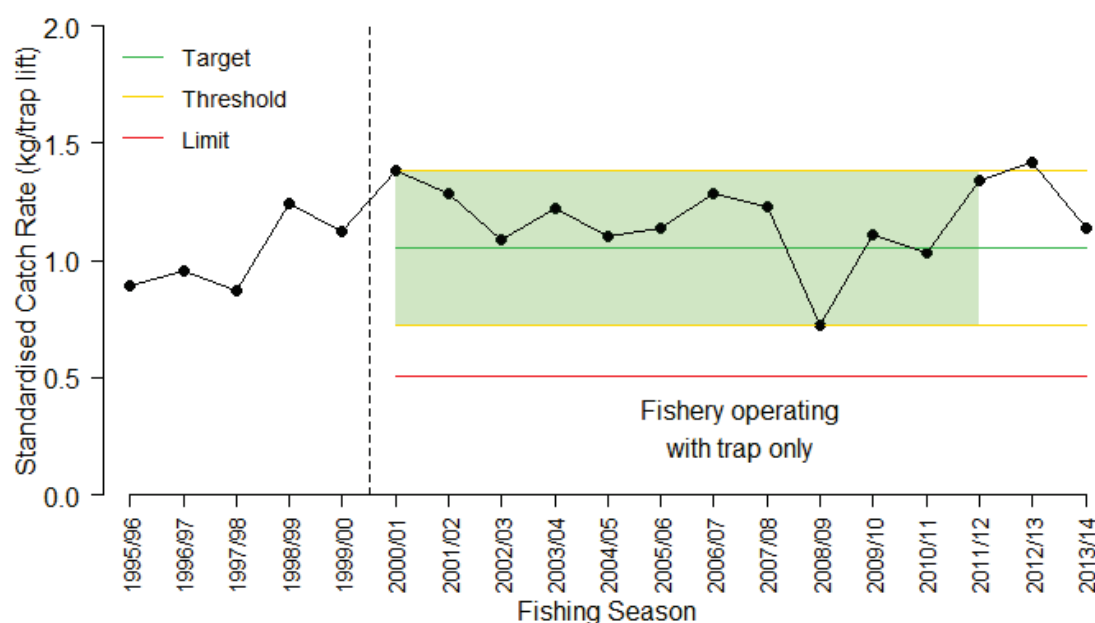


Figure 6.3 Annual standardised commercial catch rate (kg / traplift) of blue swimmer crabs in the WCEMF Area 2 relative to the associated reference points. The shaded green area reflects the reference period (2000/01 – 2011/12), from which reference points have been calculated. The start of the reference period corresponds to the time when the fishery converted to using traps for targeting blue swimmer crabs, as denoted by the vertical dashed line. Fishing season is defined as 1 November to 31 August.

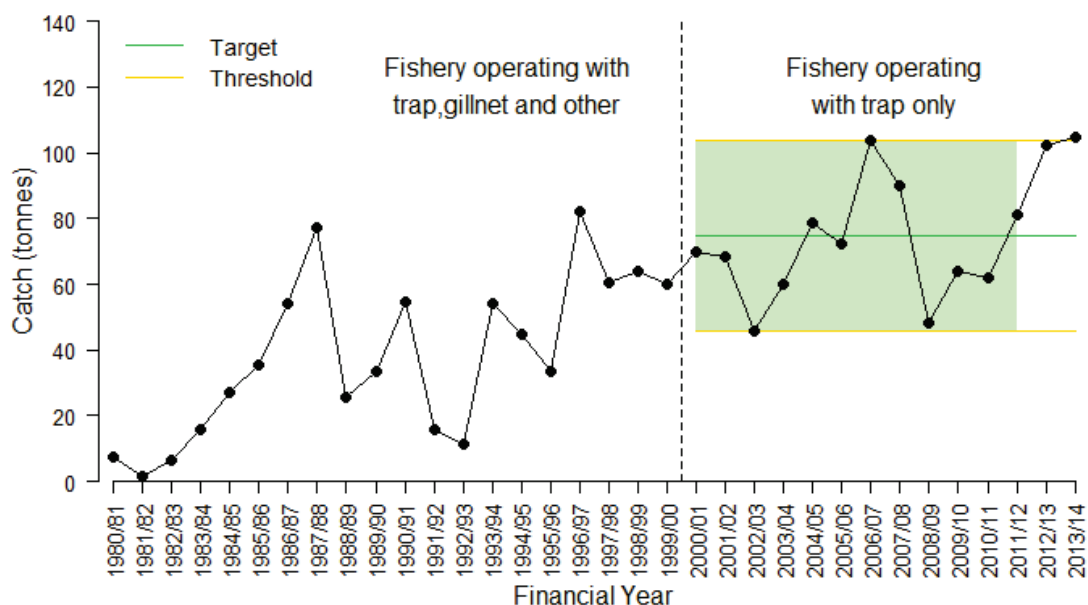


Figure 6.4. Annual commercial catch (tonnes) of blue swimmer crabs in the WCEMF Area 2 relative to the associated reference points. The shaded green area reflects the reference period (2000/01 – 2011/12), from which the reference points have been calculated. The start of the reference period corresponds to the time when the fishery converted to using traps for targeting blue swimmer crabs, as denoted by the vertical dashed line.

7. Stock Assessment

7.1 Assessment Description

7.1.1 Overview

The range of methods used by the Department to assess the status of aquatic resources in WA have been categorised into five broad levels (Fletcher & Santoro 2014), which are typically used together with a weight-of-evidence approach to consider all available information for a resource. This includes objective interpretations of the inherent vulnerability of a species to the impacts of fishing, considering factors such as longevity, recruitment patterns and stock structure, in conjunction with the operational characteristics of the fishery and the potential influences of environment (Wise *et al.* 2007). The level of assessment and monitoring in place for each target species is thus determined based on the current risk to the sustainability of the species and the size and value of the fishery (DoF 2011).

The current (Level 2) assessment of the sea mullet and blue swimmer crab resources of the PHE is based on annual monitoring of commercial catches and standardised commercial catch rates, with the latter considered a proxy for overall stock abundance. This is in accordance with the approach used by the Department for assessing data-limited stocks for which the data required (by production models) to produce reliable estimates of biomass are not available. The weight-of-evidence assessment approach involves the identification of a reference period of historical catch and catch rate data over which the fishery is considered to have been stable and maintained above B_{MSY} or a proxy for B_{MSY} (see below for how the MSC PSA approach is used in this assessment). Catch and catch rate data are then compared, on an annual basis, to reference levels (target, thresholds and limits) calculated based on data from this reference period (see Section 8.2).

A generalised linear modelling (GLM) approach to analysis of variance is used to examine the catch rates of sea mullet and blue swimmer crabs for differences among associated effects (see Sections 7.1.2.2 and 7.1.3.2). GLMs are a common method used for catch rate standardisation (Marriott *et al.* 2014), with the catch rate predicted as a linear combination of the explanatory variables that can be either categorical or continuous. The main objective of the analysis is to estimate a year effect (included in the GLM as a categorical variable) used to represent the annual relative levels of stock abundance. In the process of fitting the GLM, it must be decided which explanatory variables to include. It is desirable to incorporate all the main factors affecting catch rates into the model where possible, but this is limited by the detail of information available.

Since 2007, fishery-independent monitoring of blue swimmer crab recruitment and breeding stock levels has been undertaken in the PHE to develop more robust indices of abundance for this species (see Section 7.1.3.3). It is anticipated that, once fully tested, such indices could be used in conjunction with commercial catch and effort data in a Level 4 (i.e. Levels 1, 2 or 3 plus fishery-independent surveys of relative abundance, recruitment, etc.) assessment of blue swimmer crabs in the PHE. Some fishery-independent monitoring of sea mullet

recruitment is also currently undertaken. However, the usefulness of such data as an index of abundance has yet to be evaluated.

Due to the lack of total biomass estimates of the stocks of sea mullet and blue swimmer crabs targeted in the PHE, a risk assessment has been undertaken as a precautionary approach to the overall weight-of-evidence assessment for these stocks (see Sections 7.1.2.3 and 7.1.3.4). The PSA risk assessment approach is based on the assumption that the risk to a species depends on two characteristics: (1) the productivity of the species, which will determine the capacity of the stock to recover if the population is depleted, and (2) the extent of the impact due to the fishing activity, which will be determined by the susceptibility to the fishing activities (MSC 2013). Productivity is determined by the species life history traits, i.e. growth and maturity characteristics, trophic level and fecundity, while susceptibility is calculated using the overlap of the fishing area compared with the species range (geographical spread and depth/habitat overlap), the probability of capture if the fishing gear is encountered (e.g. species size versus mesh size) and the likelihood of post-capture survival. The scores for the seven productivity attributes and the four susceptibility attributes are combined to produce a PSA risk score for each stock.

7.1.2 Sea Mullet

7.1.2.1 Reference Period

The reference period used for setting the reference levels for the assessment of the sea mullet resource and other associated ecological assets has been set to cover a stable period in the WCEMF Area 2 (between 1 January 2000 and 31 December 2011).

During this period the evidence suggests that catches of sea mullet in the WCEMF Area 2 was sustainable. The reference period also reflects a time of stable management arrangements and environmental conditions in the fishery. Since just prior to the implementation of the *West Coast Estuarine Fishery (Interim) Management Plan* in 2003, there has been no major changes to the management arrangements for the WCEMF Area 2, except for the introduction of a two-month seasonal closure (1 September to 31 October) for blue swimmer crabs in 2007. Although this closure could potentially have resulted in shift in effort to target finfish during the closure, no change has been observed.

7.1.2.2 Catch Rate Standardisation

Standardisation of catch rates for sea mullet in the WCEMF Area 2 were initially undertaken at the beginning of 2014 (using available data for the years leading up to and including 2012), with the main objective to estimate reference levels from data collected during the reference period (see above). Although the time series has since been updated to include 2013 data, the reference levels have not been changed and will be based on the initial catch rate analysis until the current harvest strategy is due for review.

Annual commercial catch rates for sea mullet in the PHE are calculated using catch and effort data as have been recorded in statutory monthly returns and entered into the Department's Catch and Effort Statistics (CAES) database. CAES data for the netting component of the WCEMF Area 2 show that the number of commercial vessels that have fished in the PHE

using either haul or gillnets has steadily declined from ~ 50 in the 1970s to the current level of 11. However, not all of the vessels have reported annual catches of sea mullet. To reduce the influence of vessels that may only catch sea mullet occasionally, only the records of vessels that explain 80 % of total sea mullet catch in each year have been included in the analysis, assuming that the catch rate of these “primary” vessels are more likely to reflect the abundance of sea mullet.

The net fishery in the PHE is a mixed-species fishery that typically captures around 20 species of finfish each year. Sea mullet represents the main target finfish species in the fishery, comprising ~ 50 % of all reported finfish landings. Consequently, aggregated catch and effort records in the CAES database may also include effort that was actually targeting species other than sea mullet. Therefore, using catches from effort that was targeting species other than sea mullet when standardising catch rates may lead to the catch rates being an unreliable measure of abundance of this species.

To overcome the non-targeting issue when standardising the catch rates for sea mullet, a rule was identified for categorising each CAES record as ‘targeting’ or ‘non-targeting’ sea mullet. This rule is based on the proportion of the total catch of a particular CAES record that is sea mullet. For each year, a Qualification Level (QL; see Biseau 1998) is defined such that all CAES records that have sea mullet as a proportion of the reported total catch greater than or equal to this level, explain 90 % of the total sea mullet catch for that year. Vessels with records that have sea mullet greater than or equal to the year-specific QL are then identified as more likely to have targeted sea mullet.

For preliminary analyses undertaken to standardise catch rates for sea mullet, the interaction between year and fishing method was initially considered and concluded to be significant (Figure 7.1). Given the low total sum of squares explained by this interaction term compared to other factors and given that fishing method as a main effect appears non-significant this result was considered suspicious. On plotting the standardised catch rates for each fishing method by year (Figure 7.1) it is seen that the significance of the interaction between year and fishing method is due to spurious differences in some years (e.g. 1993 and 1996) and that generally, the trends in both methods compared well between years. Hence, the year by fishing method interaction was removed from further consideration.

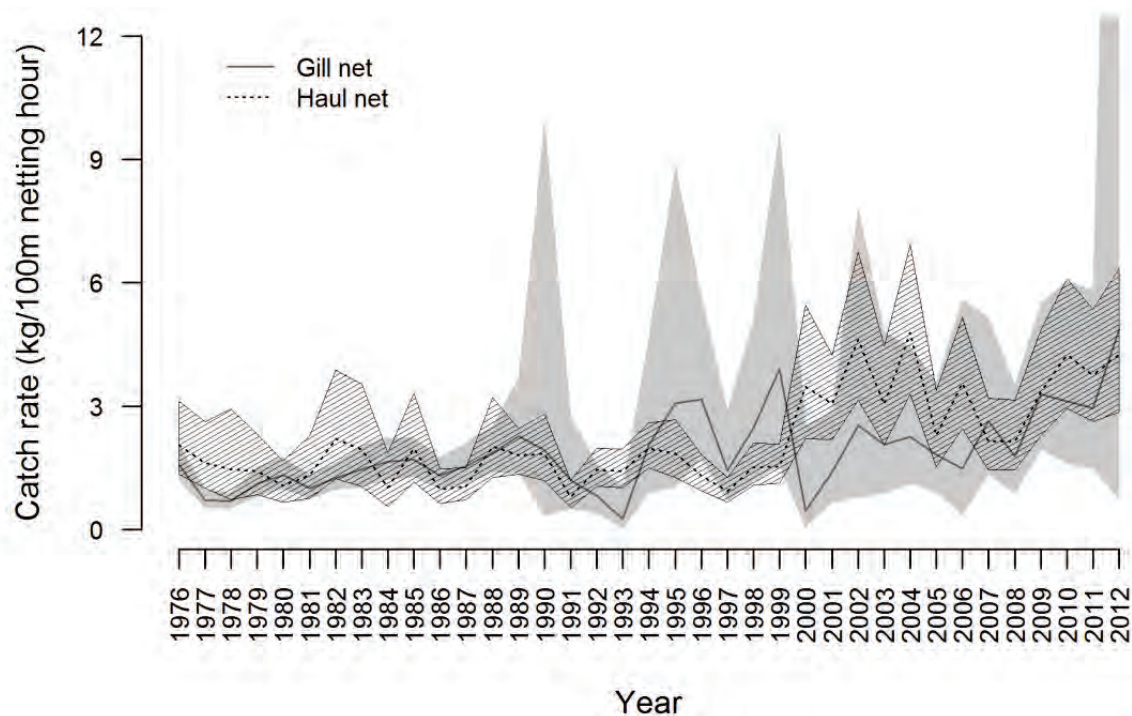


Figure 7.1. Annual standardised catch rate for sea mullet targeted by the “primary” vessels in the WCEMF Area 2 using haul and gillnets, with 95 % confidence intervals (shaded and grey areas). The presented indices have been estimated within the one model by including an interaction between year and fishing method.

The final model used to describe monthly catch rates of sea mullet in the PHE is:

$$\ln(U+0.05) = Y + M + V + F + Y:M,$$

where U is the nominal catch rate for factors year Y (1976, 1977,..., 2012), month M (Jan/Feb, Mar/Apr, May/Jun, Jul/Aug, Sep/Oct, Nov/Dec), fishing vessel V , and fishing method F (gill and haul netting). Months are paired together as a factor level to result in a ‘complete’ design so that an interaction between year and month could be included, i.e. not every month in every year had data.

The factors year, month and vessel were statistically significant at the 0.01 level, while the method factor was not (Table 7.1). The standardised annual catch rate ($\pm 95\%$ CI) for sea mullet in the WCEMF Area 2 are shown in Figure 7.2.

Table 7.1. ANOVA table (Type I and Type III sum of squares, SS) for the fitted model used to describe monthly catch rate of sea mullet in the WCEMF Area 2.

Source of variation	df	TYPE I SS	MS	F value	P value
Year	36	824.2	22.9	29.98	< 0.01
Month	5	46.8	9.4	12.26	< 0.01
Method	1	0.0	0.0	0.03	0.87
Vessel	52	879.9	16.9	22.16	< 0.01
Year x Month	180	230.0	1.3	1.67	< 0.01
Residuals	1851	1413.5	0.8		
Source of variation	df	TYPE III SS	MS	F value	P value
Year	36	163.3	4.5	5.94	< 0.01
Month	5	13.8	2.8	3.61	< 0.01
Method	1	0.3	0.3	0.41	0.52
Vessel	52	813.3	15.6	20.47	< 0.01
Year x Month	180	23.0	1.3	1.67	< 0.01
Residuals	1851	1413.5	0.8		

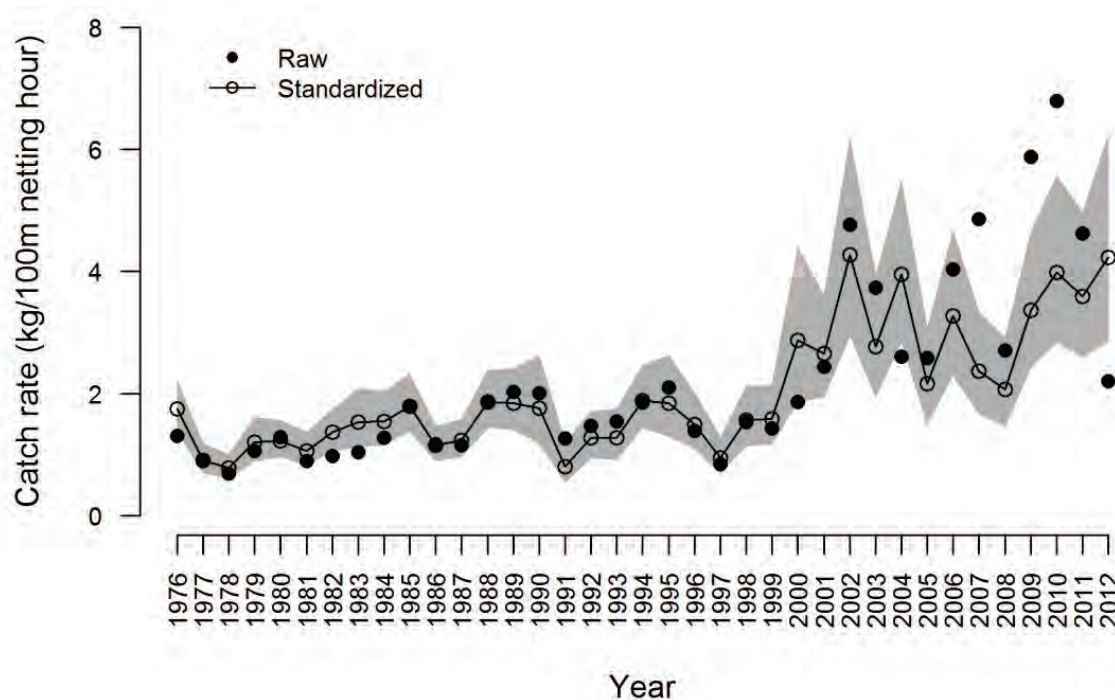


Figure 7.2. Annual raw and standardised catch rates for sea mullet targeted by the “primary” vessels in the WCEMF Area 2 using both methods (haul and gillnetting combined) with 95 % confidence intervals (grey area).

7.1.2.3 Risk Assessment

Based on a total productivity score of 1.14 and a weighted average susceptibility score for the different fisheries that target the stock in the WCB of 1.65, sea mullet achieved a total PSA score of 2.01 and an MSC score of 94.8 i.e. low risk (Table 7.2). Refer to Appendix B for full PSA including justification for scoring.

Table 7.2. PSA scores for sea mullet in the WCB.

	WCEMF Area 2 (Peel-Harvey)	West Coast Nearshore Net Fishery	South West Beach Seine Fishery	West Coast Beach Bait Managed Fishery	WCEMF Area 1 (Swan-Canning)	WCEMF Area 3 (Hardy Inlet)	Cockburn Sound Fish Net Managed Fishery	Condition 84 & 19 (Vasse- Wonnerup)
Productivity scores	(for stock)							
Average maximum age	2							
Average maximum size	1							
Average age at maturity	1							
Average size at maturity	1							
Reproductive strategy	1							
Fecundity	1							
Trophic level	1							
<i>Total productivity (average)</i>	1.14							
Susceptibility scores	(for each fishery impacting stock)							
Areal overlap	1	1	1	1	1	1	1	1
Vertical overlap	3	3	3	3	3	3	3	3
Selectivity	3	3	3	3	3	3	3	3
Post-capture mortality	3	3	3	3	3	3	3	3
<i>Total susceptibility (average)</i>	1.65	1.65	1.65	1.65	1.65	1.65	1.65	1.65
<i>Catch (tonnes)*</i>	61	22	6	0.9	0.3	2.8	0.1	2
<i>Weighting</i>	0.64	0.23	0.06	0.01	0.003	0.03	0.001	0.02
<i>Weighted Total</i>	1.06	0.38	0.1	0.02	0.01	0.05	0.002	0.04
<i>Weighted Average</i>	1.65							
PSA Score	2.01							
MSC Score	94.8 (low risk)							

*average annual catch 2009 – 2013.

7.1.3 Blue Swimmer Crab

7.1.3.1 Reference Period

The reference period for the blue swimmer crab resource in the PHE has been set to cover a period of stability in the WCEMF Area 2, i.e. since blue swimmer crab fishers converted from using gillnets to traps. This reference period was identified as between 2000/01 and 2011/12. Annual standardised catch rates of blue swimmer crabs by commercial trap are

calculated by fishing season (i.e. 1 November – 31 October), while annual commercial trap catches are reported by financial year (i.e. 1 July – 30 June).

7.1.3.2 Catch Rate Standardisation

As with the analyses undertaken to standardise the catch rates for sea mullet, analyses of blue swimmer crab catch rates were initially undertaken at the start of 2014 (using available data for the years leading up to, and including, the 2012/13 fishing season) to estimate reference levels from data collected during the reference period. Although the time series has since been updated to include data for the 2013/14 fishing season, the reference levels have not been changed and will be based on the initial catch rate analysis described below until the harvest strategy for this species is reviewed.

Annual commercial catch rates for blue swimmer crabs in the PHE are calculated using the total trap catch and effort for all commercial fishers as reported in statutory CAES returns. The nominal catch rate derived from these data is based on the number of trap lifts as a measure of fishing effort. The monthly and seasonal catch rate (catch per unit effort, CPUE) is defined as

$$CPUE_m = \frac{\sum_{i=1}^{n_f} C_{i,m}}{\sum_{i=1}^{n_f} N_{i,m}^B N_{i,m}^P}, \quad CPUE_{season} = \frac{\sum_{m=1}^{n_m} \sum_{i=1}^{n_f} C_{i,m}}{\sum_{m=1}^{n_m} \sum_{i=1}^{n_f} N_{i,m}^B N_{i,m}^P}$$

where $C_{i,m}$ is the catch of the fisher i for month m , $N_{i,m}^B$ is the number of boat days of the fisher i for month m , and $N_{i,m}^P$ is the average number of daily trap lifts of the fisher i for month m .

As the crab fishery began converting from gillnetting to trapping in 1994/95, standardisation of commercial catch rates for blue swimmer crabs in the PHE is focused solely on trap catch rates. The fishing season was limited to the first complete season of trapping data i.e. 1995/96. A GLM approach to analysis of variance was used to examine the catch rates (kg per trap) for differences among the effects of year (i.e. fishing season), month and vessel. The observed trap catch rates were standardised for temporal shifts in fishing effort that occur from month to month in each fishing year. As the PHE is contained within one CAES reporting block, it was not possible to standardise catch rates for spatial shifts in effort.

The commercial catch of the ten commercial vessels currently targeting blue swimmer crabs in the PHE formed 100 % of the total reported commercial catch since 2001/02, so the analysis was limited to these ten vessels. Due to the unbalanced nature of the data (i.e. some vessels and months of some years did not have any data), two-way interaction terms of year, month and vessel factors could not be included. However, these interactions were considered in ancillary analyses using a filtered subset of the data or by pairing levels of a factor.

The months of July and August were paired together as a factor level to result in a ‘complete’ design so that an interaction between year and month could be included, as not every month in every year had data. Although the interaction was significant, it did not contribute to a

significantly better model fit. It was noted that the variation due to this interaction was taken up primarily by the month effect in the main effect model. In the future, consideration should be given to model this term as a random effect.

As five of the ten vessels fished every season since 2001/02, with seven vessels consistent since 2003/04, a subset of data for the seven vessels consistent since 2003/04 was considered to test for possible interactions. The data of these vessels was also unbalanced. An interaction term between year and vessel was possible but not for year and month, nor vessel and month. Given the observed seasonality of blue swimmer crabs to the months of November through (and including) June and the lack of consistent fishing in months July – October, the data of these seven vessels was further restricted to these months for a secondary analysis that also allowed for the inclusion of an interaction term between year and month and vessel and month.

The model used to describe monthly catch rate of blue swimmer crabs in the PHE is:

$$\ln(U+0.5) = Y + M + V$$

where U is the nominal catch rate for factors fishing season Y (1993/94, 1994/05, ..., 2012/13), month M (Nov, Dec, ..., Aug) and fishing vessel V . Annual abundance indices were obtained from marginal means (least squares mean estimates), adjusted for the statistically significant terms.

When the data is unbalanced (unequal number of observations for each treatment), Type I sum of squares (the commonly used sum of squares in ANOVA) are dependent on the order that factors are included in the model; therefore, Type III sum of squares are also presented (these are not order dependent) to determine and describe the significance of each factor and to assess the likely stability in significance levels of the various factors in the Type I analysis (Table 7.3). All factors (year, month and vessel) were statistically significant at the 0.01 level (Table 7.3). The distributions of the standardised residuals were approximately normally distributed. The standardised annual catch rates for blue swimmer crabs in the PHE, with 95 % upper and lower confidence limits, are shown in Figure 7.3.

Table 7.3. ANOVA table (Type I and Type III sum of squares, SS) for the fitted model used to describe monthly catch rate of blue swimmer crabs in the WCEMF Area 2.

Source of variation	df	TYPE I SS	MS	F value	P value
Year	16	12.365	0.773	15.848	< 0.01
Month	9	50.932	5.659	116.050	< 0.01
Vessel	9	5.778	0.642	13.166	< 0.01
Residuals	940	45.839	0.049		

Source of variation	df	TYPE III SS	MS	F value	P value
Year	16	12.610	0.788	16.162	< 0.01
Month	9	49.799	5.533	113.469	< 0.01
Vessel	9	5.778	0.642	13.166	< 0.01
Residuals	940	45.839	0.049		

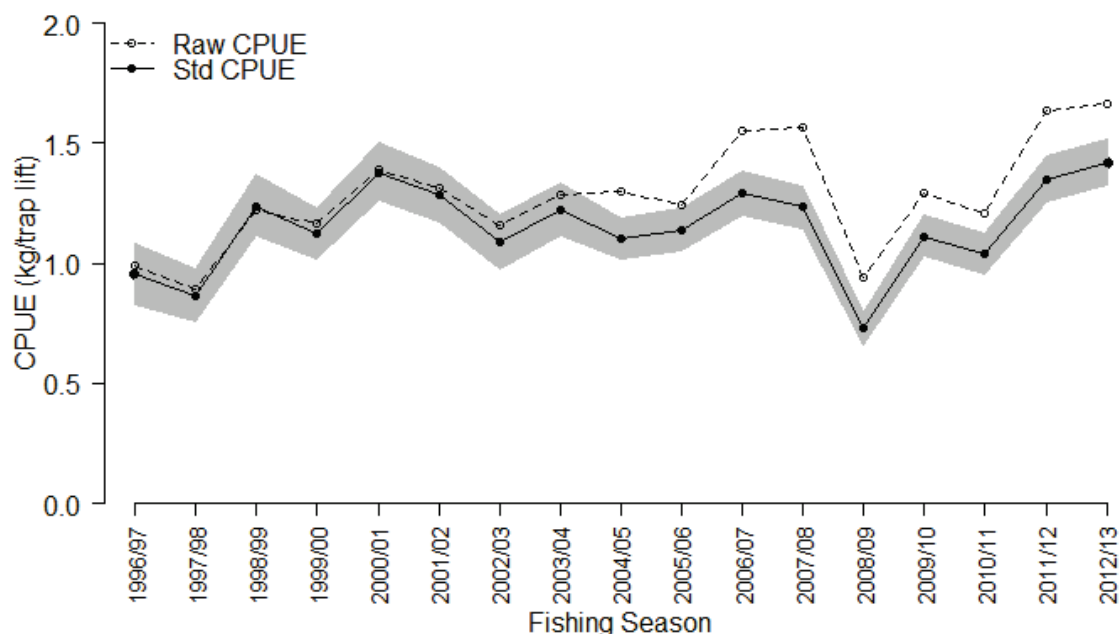


Figure 7.3. Raw and standardised catch rates (CPUE) for blue swimmer crabs targeted by the current commercial vessels in the WCEMF Area 2, with 95 % confidence intervals (grey area).

7.1.3.3 Preliminary Juvenile and Breeding Stock Indices

The fishery-independent survey that commenced in the PHE in 2007 (see Johnston *et al.* 2014a) has enabled the development of preliminary recruitment (sexually immature males and females) and breeding stock (sexually mature females) indices to assist with assessing the sustainability of the fishery (Figure 7.4 and Figure 7.5). These indices are currently used in a weight-of-evidence approach with the commercial catch and catch rates to assess the stock status. However, there is potential in the future to include the indices as performance indicators in the harvest strategy when a longer time-series of information is available, if the indicators are shown to be reliable indicators of stock status and the relationship between blue swimmer crab levels inside and outside the estuary is better understood.

Proposed future secondary performance indicators are:

- **Juvenile index:** Relative abundance of immature crabs from fishery-independent data (crabs / traplift).

In the absence of a dedicated juvenile crab trawl monitoring survey and given the current research trap sampling method is not selective for juvenile crabs < 50 mm, juvenile crab abundance is based on the standardised catch rates of crabs that are sexually immature (males < 87.1 mm CW; females < 86.9 mm CW). These crabs would potentially be legal size the following season. Fishery-independent surveys revealed the Estuary Channel sites were the region where highest abundance of immature crab was found, with the peak catch rates occurring between June to August.

Breeding stock index: Relative abundance of sexually mature sub-legal and legal females from fishery-independent data (crabs / traplift).

The breeding stock is defined as females that are sexually mature and have the potential to mate and spawn at least once before they are harvested from the estuary. The period between June and November was identified in the Estuary Channel as the best location and months for an index of sub-legal crabs as they exit the estuary with the winter rains and may not return to the estuary the following year. Although legal-sized crabs also constitute part of the breeding stock, it is unknown what proportion of the legal stock will be harvested before they mate.

Future analyses may weight females by the number of eggs produced (size-fecundity relationship) (sum of egg production = sum of eggs at a given size * Female size).

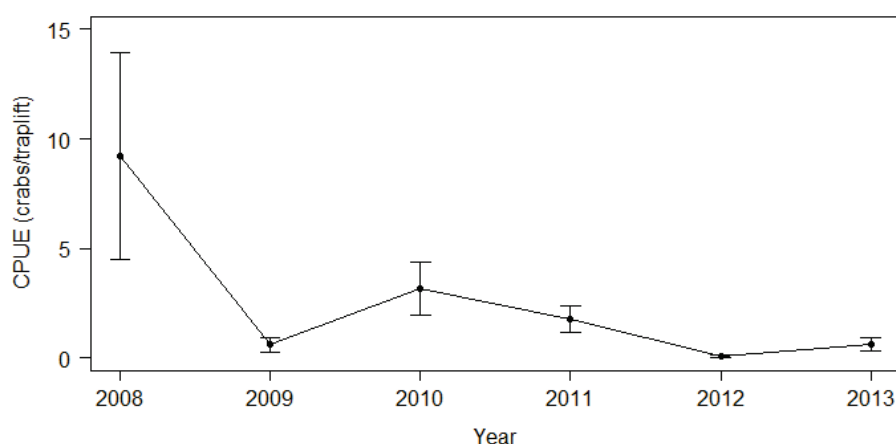


Figure 7.4. Mean (± 1 SE) catch rates (crabs / traplift) of juvenile crabs (Males < 87.1 mm CW, Females < 86.9 mm CW) sampled in Channel Estuary sites (EC1, EC2, EC3) from June to August.

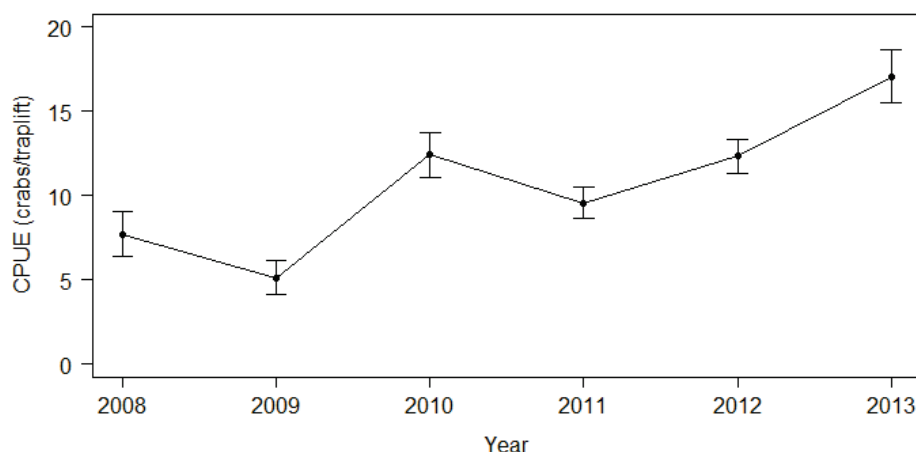


Figure 7.5. Mean (± 1 SE) catch rates (crabs / traplift) of sexually mature female crabs (≥ 86.9 mm CW) sampled in Channel Estuary sites (EC1, EC2, EC3) from June to November.

7.1.3.4 Risk Assessment

The blue swimmer crabs stock targeted in the PHE achieved a total PSA productivity score of 1.14 and susceptibility scores ranging from 1.28 to 1.88 for the different fisheries and sectors that target the stock (weighted average = 1.54; Table 7.4). This translates into a PSA score of 1.92 and an MSC score of 96.2 i.e. low risk. Refer to Appendix B for full PSA and justification of scoring.

Table 7.4. PSA scores for blue swimmer crabs in south-west WA.

	WCEMF Area 2 (Commercial trap)	WCEMF Area 2 (Recreational drop net)	WCEMF Area 2 (Recreational scoop net)	Mandurah to Bunbury Fishery (Commercial trap)	Warnbro Sound fishery (Commercial trap)	WCEMF Area 3 (haul net, trap)
Productivity scores	(for stock)					
Average maximum age	1					
Average maximum size	1					
Average age at maturity	1					
Average size at maturity	1					
Reproductive strategy	1					
Fecundity	1					
Trophic level	2					
<i>Total productivity (average)</i>	1.14					
Susceptibility scores	(for each fishery impacting stock)					
Areal overlap	2	2	1	3	1	1
Vertical overlap	3	3	3	3	3	3
Selectivity	2	2	3	2	2	2
Post-capture mortality	2	2	2	2	2	2
<i>Total susceptibility (average)</i>	1.58	1.58	1.43	1.88	1.28	1.28
<i>Catch (tonnes)</i>	83*	51^	29^	15*	26*	0.4*
<i>Weighting</i>	0.41	0.25	0.14	0.07	0.13	0.002
<i>Weighted Total</i>	0.64	0.39	0.2	0.14	0.16	0.003
<i>Weighted Average</i>	1.54					
PSA Score	1.92					
MSC Score	96.2 (low risk)					

*average annual catch 2009 – 2013.

^2011/12 adjusted estimates from IFAAC (in prep.)

7.2 Appropriateness of Assessment

The WCEMF Area 2 is data-limited as a result of its relatively low value and the small number of operators in the fishery. As neither blue swimmer crabs nor sea mullet spawn within the estuary, some natural protection is provided to the breeding stock of both species from exploitation by the WCEMF Area 2 during spawning periods. Although other fisheries are able to target these stocks in oceanic waters outside the estuary, the catches landed by these are much less than those taken in the PHE (see Section 5.1).

Annual monitoring of commercial catch and standardised catch rate data for sea mullet and blue swimmer crabs in the PHE, relative to the historical range of these values, provides an appropriate and low-cost assessment tool that enables performance against management objectives to be evaluated in accordance with the harvest strategies in place for these resources. Such control chart approaches are particularly suitable for stocks where extensive knowledge of stock biology are unavailable and / or when it is not feasible to implement ongoing biological data collection beyond the financial capacity of the fisheries concerned (Craine 2005). This approach has been widely applied in the assessment of a number of other data-limited fisheries (Saila *et al.* 1980; Mendelssohn 1981; Noakes *et al.* 1990; Freeman & Kirkwood 1995; Stergiou *et al.* 1997), some of which have undergone MSC certification (e.g. the Lakes and Coorong Fishery in South Australia; Scientific Certification Systems 2008).

In the absence of direct estimates of total biomass for sea mullet and blue swimmer crabs, and due to the lack of regular information on total recreational catch and effort of the two species, standardised commercial catch rates in the WCEMF Area 2 are used as proxies for overall stock abundance. However, it is important to recognise that the stocks also extend outside the PHE, this assessment approach is considered appropriate as the commercial WCEMF Area 2 lands the majority of the catches from the two stocks.

The use of commercial trap CPUE as a proxy for abundance of blue swimmer crabs has been successfully used in other crab fisheries in WA. For example, in Cockburn Sound, commercial CPUE in combination with other indicators of stock abundance (recruitment and breeding stock indices) were used to inform the closing of the fishery in 2006 to both commercial and recreational fishing (Johnston *et al.* 2011a, b). The commencement in 2007 of fishery-independent monitoring of blue swimmer crabs in the PHE (see Johnston *et al.* 2014a) has enabled the development of similar juvenile and breeding stock indices, which will be used to assist with assessing the sustainability of the PHE blue swimmer crab resource in the future (see Section 7.1.3.3).

Although future assessments of sea mullet in the PHE could include an age-based monitoring program to monitor rates of mortality, given the size and low risk posed by the fishery the additional financial burden may not be warranted.

7.3 Assessment Approach

The assessment approach is directly focused on ascertaining that sea mullet and blue swimmer crabs in the PHE remain above the level at which recruitment may be impaired.

This is pursued through careful and robust annual assessment of commercial catches and standardised commercial catch rates relative to specified reference points (see Section 8.2).

7.4 Uncertainty in the Assessment

As the netting component of the WCEMF Area 2 is a multi-species fishery, using catch from effort that may have been targeting species other than sea mullet can lead to catch rates being an unreliable measure of abundance of this species. Sea mullet is a highly targeted finfish species in the PHE catch, comprising > 50 % of total finfish landings. To reduce the uncertainty associated with non-targeting effort in standardising catch rates for sea mullet, year-specific QLs (see Section 7.1.2.2) were used to filter CAES records. The data used in the catch rate standardisation were restricted to only those vessels in each year that were considered, using the QLs, to be targeting sea mullet.

In calculating trapping effort for blue swimmer crabs from CAES data, the average number of traps used in a given day is multiplied by the number of boat days. As this is a generalised way of calculating effort as it is not possible to validate CAES using logbook data in this fishery, there is a degree of uncertainty in the level of trapping effort recorded. Nevertheless, standardisation of trapping catch rates against vessel, month, year, and the use of a secondary performance measure (catch) against reference points, help account for these uncertainties. The onboard commercial monitoring of the fishery by research staff and development of fishery-independent survey measures of juvenile and breeding stock levels also provide an independent check on the stock status as part of the weight-of evidence-approach.

For both sea mullet and blue swimmer crabs, within a year, catch rates between vessels are likely to differ due to factors such as skipper experience. An attempt has been made to standardise for different vessels between years by including a vessel factor in the analysis undertaken to standardise catch rates. The standardised catch rates also attempt to reduce uncertainty in the assessment by accounting for temporal shifts in fishing effort that occur from month to month in each year and between years as there is a strong monthly trend in catch rates. Given that the PHE is contained within one CAES reporting block, attempts to standardise catch rates for spatial shifts in the effort are not possible. Although the increase in fishing efficiency of vessels over time and its impact on catch rates is unknown, it is believed to be minimal due to provisions in the management plan (gear and vessel constraints) and limited to increased skipper knowledge.

Some uncertainty exists regarding the stock structure of sea mullet in the WCB. The population within WA is thought to be comprised of a genetically homogeneous stock (due to wide oceanic egg and larval dispersal and adult migration, see Section 2.1.2). However, a precautionary approach has been adopted to manage the sea mullet stock on a bioregional basis.

7.5 Evaluation of Assessment

Analyses undertaken to standardise catch rates for both sea mullet and blue swimmer crabs account for differences across vessels, months and years to assess the performance of the fishery. For both species, variations of the final catch rate standardisation model were

considered, e.g. including targeting variables versus removing non-targeted data, including and excluding year and vessel interaction, and using only data for years where each month has catch data versus using all years but combining months. Suitable models for final consideration were selected based on their diagnostic plots exhibiting no concerns to model assumptions and that they demonstrated a good ability to demonstrate historical trends. The final model chosen was selected based on its ability to produce a more extensive time series (inclusion of different terms may have restricted the years for which it could provide estimates) and given its robustness to replicate estimates from the other models.

7.6 Peer Review of Assessment

Internal reviews of the assessments of sea mullet and blue swimmer crabs in the PHE are undertaken annually as part of the process for completing the annual *Status Reports of the Fisheries and Aquatic Resources in Western Australia: the state of the fisheries* (e.g. Fletcher & Santoro 2014). An external review of the blue swimmer crab fishery in the PHE was undertaken by Dr Wayne Sumpton (Senior Fisheries Biologist, Department of Agriculture and Fisheries, Queensland) in 2010 (see Appendix C).

The Department's catch and catch rate-based assessment approach for data-poor species has been reviewed internally. In addition, the development of time series / statistical control charting approaches for application in the management of WA fisheries was undertaken by Craine (2005) which was externally reviewed.

8. Harvest Strategy

Harvest strategies for the finfish and blue swimmer crab resources of the PHE (DoF 2015a, b) make explicit the management objectives, performance indicators, reference levels and harvest control rules for the resources, which are taken into consideration by the Department when preparing advice for the Minister for Fisheries. The harvest strategies have been developed in line with the Department's over-arching Harvest Strategy Policy (DoF 2015c) and relevant national policies / strategies (ESD Steering Committee 1992) and guidelines (e.g. Sloan *et al.* 2014). In addition, to target species (i.e. sea mullet and blue swimmer crabs) they also incorporate retained non-target species, bycatch, ETPs, habitats and ecosystem components to ensure the risks to these elements are effectively managed.

8.1 Framework

This section provides a summary of the harvest strategy framework in place for managing the sea mullet and blue swimmer crab resources of the PHE (see also DoF 2015a, b). Additional information about the reference points and associated harvest control rules specified for these species is provided in Section 8.2 and 8.3. Information and monitoring undertaken to inform the harvest strategies and the overall weight-of-evidence approach used for assessing the status of these resources are outlined in Section 8.4.

8.1.1 Design

The harvest strategies are based on a *constant proportion approach*, where the annual catch of the targeted resource varies in proportion to variations in stock abundance. To achieve this, sea mullet and blue swimmer crabs in the PHE are assessed annually by comparing standardised commercial catch rates and commercial catch (i.e. the performance indicators) against reference points, which are calculated based on commercial catch and effort data from a reference period when the effort levels in the fishery were stable (see Section 8.2 for more detail).

Recognising that the stocks of both sea mullet and blue swimmer crabs in the PHE also extend outside the estuary, it should be noted that the harvest strategies for these resources assume that the standardised commercial catch rates for the two species in the PHE are indicative of the overall stock abundance. The commercial data are thus used as proxies for the recreational components of the fisheries due to the lack of regular and robust estimates of recreational catch and effort in the PHE. Therefore, the harvest strategies are considered responsive to overall stock status and work towards meeting the specific long- and short-term management objectives for these resources (DoF 2015a, b).

Harvest control rules define what management actions should occur in relation to the value of each indicator compared to the reference levels (see Section 8.3). The extent of management actions taken (e.g. to reduce catches) will be determined by the extent to which a performance indicator has breached a threshold or limit reference point. The management measures available for reducing catches of sea mullet and blue swimmer crabs in a situation where a threshold or limit level is breached will differ for the two species and for the different fishing sectors (i.e. commercial and recreational) (see Section 13.4.1.3.2).

8.1.2 Evaluation

It is unlikely that recruitment of sea mullet or blue swimmer crabs would be impaired at the current level of catch and effort in the WCEMF Area 2. The relative consistency, for each of the two species, of annual commercial standardised catch rates and catch during the reference period and in subsequent years (see Figure 6.1 – Figure 6.4) indicates that the harvest strategies for these resources should continue to maintain the stocks around their target levels.

The commercial catch rate for blue swimmer crabs in the WCEMF Area 2 decreased significantly in the 2008/09 fishing season, which was consistent with a decline in catch at this time (Figure 6.3, Figure 6.4). In accordance with the harvest strategy, a review was undertaken to investigate possible reasons for this variation. Factors that may have contributed to the low blue swimmer crab catches observed in 2008/09 included higher than normal numbers of sublegal crabs, an increase in the minimum retention size for market purposes, and a reduction in effort by some fishers. The standardised commercial catch rate of blue swimmer crabs increased between 2008/09 and 2012/13 and is currently in the target range (Figure 6.3).

As described in Section 7.2, commercial trap catch rate, as an indicator of abundance of blue swimmer crabs, has been successfully used in the past to inform management actions in the Cockburn Sound Crab Managed Fishery in the south-west WA. Management action has also been triggered in other WA fisheries in response to specified reference points for target species being breached (see Section 8.3.1 for an example from the West Coast Rock Lobster Fishery).

8.1.3 Monitoring

Monthly statutory catch and effort data from the WCEMF Area 2 is used as the basis for ongoing monitoring of the sea mullet and blue swimmer crab resources of the PHE (see below in Section 8.4.2.1.1). For the two target species, the primary indicator in the harvest strategy (standardised commercial catch rate in the WCEMF Area 2, which represents a proxy for overall stock abundance) is collated from the monthly CAES returns provided by fishers to the Department. A secondary indicator, commercial catch of each species, is also monitored on an annual basis using these data.

Although not directly used in the harvest strategy, additional biological data for blue swimmer crabs (i.e. size structure, sex ratios) have been collected from onboard commercial monitoring since 2007 (Section 8.4.2.1.2). Fishery-independent surveys of blue swimmer crab juvenile and breeding stock levels have also been undertaken since 2007 (Section 8.4.2.3.2).

8.1.4 Review

The harvest strategies for the finfish and blue swimmer crab resources of the PHE were developed via consultation with industry, the Western Australian Fishing Industry Council (WAFIC) and Recfishwest and have been approved by the Director General of the Department of Fisheries and the Minister for Fisheries.

The harvest strategies will remain in place for a period of five years, after which they will be fully reviewed. However, given that these are the first harvest strategies for these resources, the documents may be subject to further review and amended as appropriate within the five-year period.

8.2 Reference Points

8.2.1 Appropriateness of Reference Points

In the absence of direct estimates of sea mullet and blue swimmer crab total biomass, reference points (targets, thresholds and limits) for the two species have been calculated from standardised commercial catch rates and catches observed during a reference period. The reference period for sea mullet is 1 January 2000 and 31 December 2011. For blue swimmer crabs, the reference period is 1 November 2000 – 31 October 2011, whilst catches are analysed by financial year for the reference period (i.e. 1 July 2000 – 30 June 2011).

Given the relatively small size and low economic value of the WCEMF Area 2, the use of catch rate and catch-based reference points is appropriate as they are calculated from data collected during a period characterised by stable (and, with regards to sea mullet, historically low) catches and effort in the fishery. Therefore, they are considered to be conservative and highly likely to maintain a sustainable fishery.

8.2.2 Level of Target Reference Points

As part of the current process to standardise the method of calculating reference points used for fisheries in WA with catch rate and catch-based stock assessments, catch rate and catch-based target ranges for sea mullet and blue swimmer crabs in the PHE extend between the minimum and maximum values recorded during the reference period. This target range ensures the stocks remain above B_{MSY} (see Section 7.1.1). Values for the target reference levels specified for the sea mullet and blue swimmer crab resources of the PHE are:

- Sea mullet Annual standardised commercial (haul and gillnet) catch rate is 2.2 – 4.6 kg / 100 m netting hour; and
Annual commercial (haul and gillnet) catch is 46 – 70 t.
- Blue swimmer crab Annual standardised commercial (trap) catch rate is 0.7 – 1.4 kg / traplift; and
Annual commercial (trap) catch is 45 – 104 t.

8.2.3 Level of Threshold Reference Points

The threshold reference points for sea mullet and blue swimmer crabs in the PHE correspond to the minimum and maximum values of catch rates and catches observed during the reference period. These threshold levels provide an early warning to initiate management actions so that an appropriate level of response is generated to avoid the indicator reaching the limit level. The threshold reference points for the two species are:

- Sea mullet Annual standardised commercial (haul and gillnet) catch rate is < 2.2 kg / 100 m netting hour or > 4.6 kg / 100 m netting hour; and
Annual commercial (haul and gillnet) catch < 46 t or > 70 t.
- Blue swimmer crab Annual standardised commercial (trap) catch rate is < 0.7 kg / traplift or > 1.4 kg / traplift; and
Annual commercial (trap) catch is < 45 t or > 104 t.

8.2.4 Level of Limit Reference Points

The limit reference levels for sea mullet and blue swimmer crabs have been calculated as a percentage of the lower catch rate threshold value for each of the two species. The percentage is fishery-dependent and, following experience in the West Coast Rock Lobster Fishery, the limit reference points have been calculated as 70 % of the lower catch rate threshold value for each of the two species. Given these are data-limited stocks, this percentage value was chosen as it is considered more conservative than the general limit reference level of 50% B_{MSY} . The limit reference points for the two species are:

- Sea mullet Annual standardised commercial (haul and gillnet) catch rate is < 1.6 kg / 100 m netting hour.
- Blue swimmer crab Annual standardised commercial (trap) catch rate is < 0.5 kg / traplift.

8.3 Control Rules and Tools

8.3.1 Design and Application

The harvest control rules in place to regulate the level of exploitation on sea mullet and blue swimmer crabs in the PHE are consistent with the harvesting approach and control commercial and recreational fishing effort applied to the stocks to ensure that catch and catch rates remain within their target ranges (Figure 8.1).

If the annual standardised commercial catch rate and / or catch of either resource breaches a threshold level, a review / investigation will be undertaken considering all available information relevant for determining the likely cause for the variation (e.g. fishing-related, economic or environmental conditions). If there is evidence to suggest that a breach of the threshold is due to a decline in the spawning biomass of the target stock, appropriate management action will be taken to reduce total catches (commercial and recreational) and return the indicator(s) to the target level(s). The threshold levels are designed to ensure that management actions will be taken before a stock breaches the limit level, minimising the risk of recruitment being impaired.

If the primary performance indicator (standardised commercial catch rate) of either resource falls outside the limit level, management action will be taken to protect the breeding stock by

reducing total catch by 50 – 100 % (i.e. potentially implementing a full closure of the fishery).

In situations where an assessment and subsequent harvest strategy review indicates that a reduction in total catches of a resource is required to return the stock to target levels, management actions will be tailored for the commercial and recreational fishing sectors to ensure that sectors maintain their respective catch share (i.e. if a reduction in total catch is required it will be implemented in accordance with any existing sectoral allocations).

The ability to implement management actions to reduce commercial and recreational effort and catches in the WCEMF Area 2 is provided through the *West Coast Estuarine Managed Fishery Management Plan 2014* and relevant powers under the FRMA. The authority to adjust management is held by the Minister for Fisheries (see Section 12.1), with a number of management measures already in place for sea mullet and blue swimmer crabs (Section 4), which can be amended as needed to ensure each fishing sector is achieving the resource objectives. The implementation of new management measures may also be considered if required.

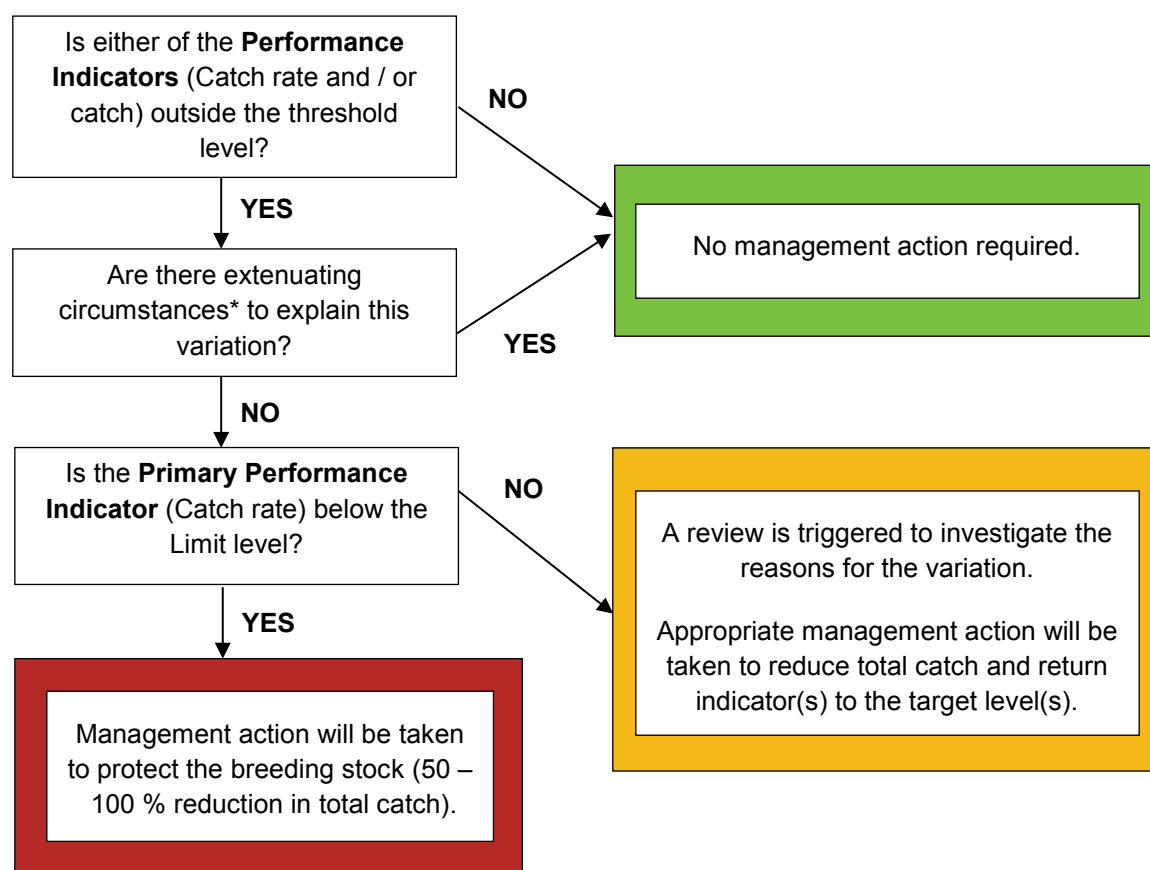


Figure 8.1. Flowchart of generic harvest control rules for the sea mullet and blue swimmer crabs resources of the PHE. *Extenuating circumstances include market forces, environmental effects, etc.

Frameworks to inform management decisions are in place for a number of other fisheries in WA and have been effective in triggering action in the past where required. For example, a

decision rule framework for the West Coast Rock Lobster Fishery was first developed more than a decade ago⁴ and has since been formalised into a harvest strategy for this resource (DoF 2013). The original decision rule framework was in place during the late 2000s, when management action was taken in the fishery in response to low recruitment of western rock lobster (DoF 2008). Nominal fishing effort reductions of 44 and 72 % were taken in 2008/09 and 2009/10, respectively, such that breeding stock could be maintained above threshold levels in the following five year period during which low catches had been predicted (de Lestang *et al.* 2012). The resulting large reductions in catch (up to 4400 t) lead to significant increases in residual biomass, which have since flowed into the available stock.

8.3.2 Accounting for Uncertainty

There is some uncertainty associated with the use of the primary indicator (catch rate) for detecting a declining abundance of the target species. This is particularly the case for sea mullet, because the multispecies nature of the netting fishery in the PHE makes it difficult to assess the level of targeted effort on this species. There is also uncertainty in the calculation of effort for blue swimmer crabs in the PHE as the number of traps per day per fisher is an average for the month. The process undertaken each year to standardise catch rates of sea mullet and blue swimmer crabs accounts for some of the uncertainty (see Section 7.4).

The tracking of multiple performance measures against reference points through the use of a secondary indicator (catch) further helps to deal with uncertainties. This precautionary approach thus ensures that any changes to the catch rates or catches of target species, which may suggest declines in stock abundance, will be detected.

The review step of the harvest control rule, which is undertaken when the threshold is triggered (see above) accounts for uncertainty in the performance measure by extending the assessment to account for other available information (e.g. effort, changing fleet composition, market forces, other biological information) to evaluate if the breach of reference point was due to a decline in stock biomass. The availability of onboard commercial trap monitoring data and fishery-independent surveys of the blue swimmer crab resource in the PHE provides additional information relevant to a weight-of-evidence assessment of this resource.

8.3.3 Evaluation

The harvest control rules for sea mullet and blue swimmer crabs in the PHE are appropriate and effective in controlling exploitation of the breeding stock. Information on which the harvest control rules are based is assessed annually, with some indicators monitored on a more frequent basis to detect any changes in fishing behaviour during the fishing season. This is particularly the case for blue swimmer crabs, where data from monthly commercial monitoring and a fishery-independent sampling program also provide supplementary information used for monitoring the status of the stock.

⁴ Draft report available at:
http://www.fish.wa.gov.au/Documents/rock_lobster/Decision_rules_framework_public_consultation_draft_2004.pdf

The management system in place ensures that immediate management actions can be taken if required. The ability to implement urgent and substantial management changes in response to declining spawning biomass has been demonstrated in the other blue swimmer crab fisheries. For example, the Cockburn Sound blue swimmer crab fishery was closed to all commercial and recreational crab fishing in 2006 (Johnston *et al.* 2011) and again in 2014, in response to low catch rates and other indices of stock abundance (recruitment and breeding stock levels).

There is evidence that the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery is currently operating at sustainable levels (Section 6.1). The fact that catch rates and catches of blue swimmer crabs and sea mullet are fluctuating around their respective target levels is consistent with achieving the desired harvest level under current management arrangements.

8.4 Information and Monitoring

8.4.1 Range of Information

There is a range of information available to support the harvest strategies for sea mullet and blue swimmer crabs in the PHE (Table 8.1 and

Table 8.2, respectively).

Research and monitoring has been conducted in the PHE since the 1970s and has provided a broad understanding of the biological characteristics of sea mullet and blue swimmer crabs in the estuary (see Section 2). Information on catch and effort of the commercial sector are monitored on monthly (Section 8.4.2.1), while estimates of recreational catches are available from shore- and boat-based recreational fishing surveys (Section 8.4.2.2). Some fishery-independent information on recruitment, juvenile and breeding stock levels of sea mullet and blue swimmer crabs are also available (Section 8.4.2.3).

Table 8.1. Summary of information available to support the harvest strategy for sea mullet in the PHE.

Data type	Fishery-dependent or independent	Analyses and purpose	Areas of collection	Frequency of collection	History of collection
Commercial catch and effort statistics (CAES)	Dependent	Catch and effort trends	PHE	Monthly	Since late 1970s
Voluntary commercial logbooks	Dependent	Provide supporting information on targeting by gear type	PHE	Daily	1982 – 1998 2006 – 2008
Recreational fishing surveys	Dependent	Catch estimates/shares	PHE	Periodic	Since 1996/97
Voluntary recreational logbooks	Dependent	Targeting, release rates, methods	PHE	Daily	Since 2004
Charter vessel logbooks	Dependent	Catch estimates/share	WCB	Monthly	Since 2002
Biological information	Dependent and independent	Patterns of growth and reproduction, stock structure	PHE and other WCB sites	Occasional	Since 1970s
Fishery-independent surveys	Independent	Developing forecast of recruitment strength	Nearby oceanic sites – Bunbury, Warnbro, Leschenault Inlet	Monthly	Since 1993/94

Table 8.2. Summary of information available to support the harvest strategy for blue swimmer crabs in the PHE.

Data type	Fishery-dependent or independent	Analyses and purpose	Areas of collection	Frequency of collection	History of collection
Commercial catch and effort statistics (CAES)	Dependent	Catch and effort trends	PHE	Monthly	Since late 1970s
Commercial monitoring	Dependent	Commercial catch composition	PHE	Monthly	1998-2001 Since 2007
Recreational fishing surveys	Dependent	Catch estimates/shares	PHE/WCB	Periodic	Since 1998/99
Biological information	Dependent and independent	Patterns of growth and reproduction, stock structure	PHE/WCB	Occasional	Since 1970s
Fishery-independent surveys	Independent	Catch composition and catch rates of juvenile and breeding stock	PHE	Monthly (Jun – Nov)	2007 – 2012 Since 2013

8.4.2 Monitoring

8.4.2.1 Commercial Fishing Information

8.4.2.1.1 Monthly Reporting

Licencees involved in fishing operations and / or the master of every licensed fishing boat are required by law to submit accurate and complete catch and effort returns on forms approved by the Department (see Appendix D).

This information has been collected by the Department for the WCEMF Area 2 since the late 1970s in the form of statutory monthly catch and effort (CAES) returns. These returns record monthly catch totals (to the nearest kilogram) for each retained species, monthly effort (total days fished), estimates of daily effort (e.g. trap lifts per day, average hours fished per day, average length of net deployed per day) and spatial information (by CAES block) for each method (e.g. trap, gillnet, haul net).

Commercial catch and effort data are collected and collated by the Department in the CAES database. The data reported by fishers are checked for errors and inconsistencies prior to entry into the database, after extraction from the database and prior to analysis. The CAES data submitted by trap fishers in the WCEMF Area 2 is also validated by commercial monitoring information collected by research staff on board commercial vessels (see below).

The monthly commercial catch and effort data for sea mullet and blue swimmer crabs in the WCEMF Area 2 are used to calculate annual standardised catch rates for each species that are

used, along with annual commercial catches, to inform the harvest strategies for these resources. Summaries of commercial catch and effort trends in the WCEMF Area 2 for sea mullet and blue swimmer crabs are provided in Section 3.1.4.

Voluntary daily catch and effort returns for netting have been trialled in the WCEMF Area 2 (1982 and 2006) and have provided important background information on target and byproduct species in the finfish fishery.

8.4.2.1.2 Blue Swimmer Crab Commercial Monitoring

Historical commercial monitoring

The first commercial catch monitoring program for blue swimmer crabs in the PHE ran from December 1998 to June 2001 (Melville-Smith *et al.* 2001). During this program, the estuary was sampled twice a month, recording data on catches, size composition, sex ratio and breeding status of blue swimmer crabs, as well as environmental conditions, such as salinity and water temperature recorded at some sites.

Current commercial monitoring

The current commercial catch monitoring program for the WCEMF Area 2 was established in March 2007 (Johnston *et al.* 2014a). As part of the current program, Departmental research staff board one commercial fishing vessel operating in the Peel Inlet region and one operating in the Harvey Estuary region each month. However, this is not always possible, with fishers operating solely in either the Peel Inlet or the Harvey Estuary in some months.

Initially, the current commercial monitoring continued during the seasonal closure (September and October) to determine the potential catch dynamics during this period. However, due to budgetary constraints, the funding required for monitoring during these two months has been suspended.

As part of the current monitoring regime (see Johnston *et al.* 2014a for more detail), commercial blue swimmer crab data are collected from up to 84 traps for each month of sampling (up to 42 in the Peel Inlet and the Harvey Estuary each). Baited traps are placed along a “crab-line” (which could vary in the number of traps) over a 24-hour soak duration. As each trap is pulled, the size (CW), sex, berried status and shell condition (soft or hard) of each captured crab is recorded. The GPS coordinates of the start location of each crab line is also recorded (Figure 8.2) and each traplift location is determined to be in either the Peel or Harvey region, based on the following coordinates:

Latitude < (1.54 x Longitude - 145.53) = Peel Inlet

Latitude > (1.54 x Longitude - 145.53) = Harvey Estuary

This information is used to determine seasonal patterns of commercial effort (see Section 3.1.3.2) and the ratio of females to males throughout the PHE (see Appendix A). Comparisons between historical and current monitoring program are limited as location data

was not accurately recorded in the initial monitoring program, making spatial and seasonal comparison between the two programs difficult.

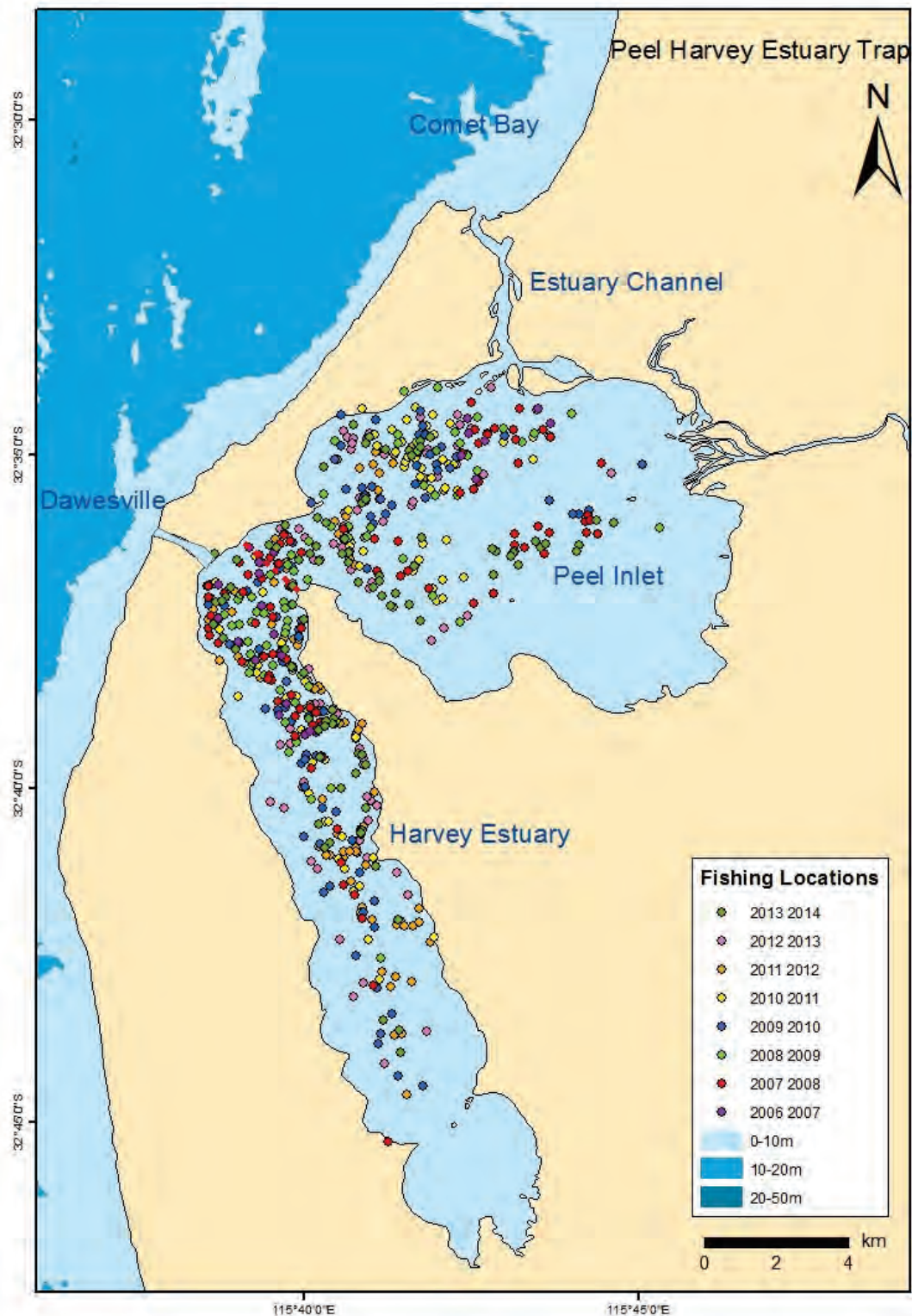


Figure 8.2. Locations of trap lines sampled during commercial catch monitoring surveys aboard commercial vessels in the WCEMF Area 2 between March 2007 and June 2014. Data is presented over the financial year; July to June.

8.4.2.2 Recreational Fishing Information

Estimates of recreational catches and effort in the PHE are available from periodic fishing surveys undertaken by the Department. While some of the surveys have focused solely on the estuary (Malseed & Sumner 2001; Lai *et al.* 2014), others have provided broad-scale estimates of recreational fishing catch and effort in the WCB and / or the entire State (e.g. Ryan *et al.* 2013).

8.4.2.2.1 Blue Swimmer Crab Recreational Fishing Surveys

1998/99 and 2007/08 Peel-Harvey Estuary Surveys

To date, two dedicated recreational fishing surveys have been undertaken in the PHE in 1998/99 and 2007/08 (Malseed & Sumner 2001; Lai *et al.* 2014). These surveys included recreational boat- and shore-based fishers, with a focus on those fishers targeting blue swimmer crabs.

Due to the different fishing methods (e.g. boat-based recreational fishers typically use drop nets when fishing for blue swimmer crabs, while shore-based fishers may use both drop and scoop nets) different survey approaches were required for each component. Thus, fishers crabbing from boats were interviewed at the conclusion of fishing on return to boat ramps, fishers at bridges/jetties and at scoop netting areas were interviewed while fishing by interviewers who progressively traversed the bridge, jetty or shoreline from which fishers were crabbing and logbooks were issued to fishers crabbing from their private houses along canals or who hired houseboats (Lai *et al.* 2014).

Each survey spanned a 12-month period and was stratified by season, time of day, weekdays or weekends and area (with each area further stratified by boat ramp). In 1998/99, the boat-based and houseboat surveys extended from August 1998 to July 1999, the scoop netting survey from December 1998 to April 1999 and the bridge and jetty survey ran from November 1998 to April 1999 (Malseed & Sumner 2001).

The design used for the 2007/08 recreational survey was a refinement of that employed for the earlier 1998/99 survey (Lai *et al.* 2014). Thus, it extended over a greater period within each survey day and although still stratified to provide greater precision during the peak fishing period, covered the full year for the shore-based fishing component rather than the restricted period surveyed in 1998/99. Therefore, the 2007/08 surveys of boat-based fishing, and fishing from bridges/jetties, scoop netting areas, private houses along canals and houseboats ran from November 2007 to October 2008 (Lai *et al.* 2014).

Estimates of catch (numbers retained and released) and effort within each of these separate components of the recreational fishery were calculated. A random sample of blue swimmer crabs and finfish from each fisher were also measured during the interview (Malseed & Sumner 2001; Lai *et al.* 2014). It is important to note that estimates of recreational catch of blue swimmer crabs from these surveys do not account for recreational fishing undertaken outside of daylight hours (Lai *et al.* 2014).

The methods used for analysis of the 2007/08 survey data were modified from those employed for the 1998/99 survey to accommodate the outcomes of the Aldo Steffe review of the survey methods described by Sumner *et al.* (2008) and the advice from a recreational survey workshop held in 2010 (Wise & Fletcher 2013). Thus, greater attention was given to the calculation of estimates of uncertainty and statistical analyses were extended to explore the consequences of alternative methods yielding slightly different estimates of catch and fishing effort. For consistency and to facilitate comparison with the results of the 2007/08 survey, the results of the 1998/99 survey were also re-analysed using the modified approaches (see Lai *et al.* 2014).

2011/12 and 2013/14 Statewide Boat-Based Recreational Fishing Surveys

More recently, a state-wide integrated survey has been implemented to collect information on (licensed) boat-based recreational fishing in WA (Ryan *et al.* 2013). This survey system uses three complementary components, an off-site phone diary surveys, on-site boat ramp surveys and a remote camera survey, to collect information on fishing catch, effort, location and other demographic information every two years. Surveys have been conducted in 2011/12 (Ryan *et al.* 2013) and 2013/14 (Ryan *et al.* in prep.) using this methodology. Although these surveys provide estimates of the boat-based blue swimmer crab catch in the PHE, they do not provide estimates of the shore-based recreational catch of blue swimmer crabs, as shore-based fishers are not licensed and therefore were not included in the sample frame.

Other Monitoring Programs

A new project is underway to investigate the potential to monitor shore-based recreational fishing for blue swimmer crabs by installing cameras along the PHE foreshore. The cameras run 24-hours a day, seven days a week at four locations around the estuary. Analysis of the data will identify patterns of recreational fishing activity over 24-hours, throughout the year. The installation of cameras commenced in December 2014 and recreational fishing activity will be monitored throughout the 2015 calendar year. If cameras are maintained beyond 2015, they may provide an ongoing means to monitor recreational fishing activity at these four locations.

8.4.2.3 Fishery-Independent Information

8.4.2.3.1 Finfish Recruitment Surveys

In 1993, the Department commenced annual, large-scale, fishery-independent surveys of juvenile (0+) finfish abundance at coastal sites along the lower west and south coasts of WA. These surveys aimed to monitor the annual recruitment of juveniles of important recreational and commercial species to assess relative stock abundance and potentially predict fishery landings.

Preliminary analyses of the relationships between annual recruitment trends, fishery catch rates and environmental factors were conducted for a number of species (including Australian herring and sea mullet) after six years of recruitment monitoring (Gaughan *et al.* 2006). Fishery-independent recruitment indices for Australian herring were re-examined using

additional data as part of a recent stock assessment of this species in south-western Australia (Smith *et al.* 2013). However, the suitability of this approach to determine the relative abundance of other species such as sea mullet has not been fully assessed.

8.4.2.3.2 Blue Swimmer Crab Research Surveys

Since the 1980s, there have been intermittent fishery-independent research surveys of the blue swimmer crab population in the PHE (Potter *et al.* 1983; de Lestang 2002; Johnston *et al.* 2014a). These surveys used different capture methods, study periods, and locations, and therefore only provide snapshots of the catch composition and distribution. However, collectively, the data highlight critical aspects of the life-history, stock structure and changes in population dynamics over time.

The current fishery-independent survey program commenced in June 2007, using methods which replicate the sampling design of de Lestang (2002) to compare the current status of blue swimmer crabs in the PHE with historical data (Johnston *et al.* 2014a).

Initially, this program used both trawl and trap methods in order to replicate sites and methods used by de Lestang (2002) and produced a comparable dataset. Otter trawling was conducted monthly from February 2007, sampling six sites in the Harvey Estuary, six sites in the Peel Inlet and three sites in the Estuary Channel (Figure 8.3; Table 8.3; refer to Johnston *et al.* 2014a for a detailed description of methods). However, trawl efficiency was reduced by the filamentous green algae *Chaetomorpha* and *Cladophora* in the estuary and trawl sampling ceased in January 2009.

When the trap sampling program began in June 2007, three traps were deployed at each of five selected trawl sites, since December 2007 three traps have been set at all 15 PHE trawl sites (Figure 8.3; Table 8.3; Johnston *et al.* 2014a). At each site, baited traps are deployed 50 m apart for 24-hours. The traps are approximately 116 cm in diameter, 40 – 50 cm in height, with 2 inch mesh size and no escape gaps to capture of both juvenile and sub-legal blue swimmer crabs (Figure 8.4).

Between 2007 and 2012, trap sampling at each site was undertaken once a month, with size (CW), sex, berried status and shell condition (i.e. soft or hard) recorded for each trap (Johnston *et al.* 2014a). Additional traps were deployed at selected sites outside the estuary in oceanic waters from August 2008 to December 2011 to provide information on blue swimmer crab abundance, composition and movement between estuarine and oceanic waters (see Johnston *et al.* 2014a). At each site (Figure 8.3; Table 8.3), five baited traps were deployed ~ 100 m apart for 24-hours.

Following a review of the fishery-independent sampling program in 2013, the number of months sampled was reduced to six (June – November). This period provides an estimate of blue swimmer crab abundance as they exit the estuary during autumn / winter months and, for legal-sized crabs, provides an indication of the residual legal biomass after the peak fishing period (Johnston *et al.* 2014a).

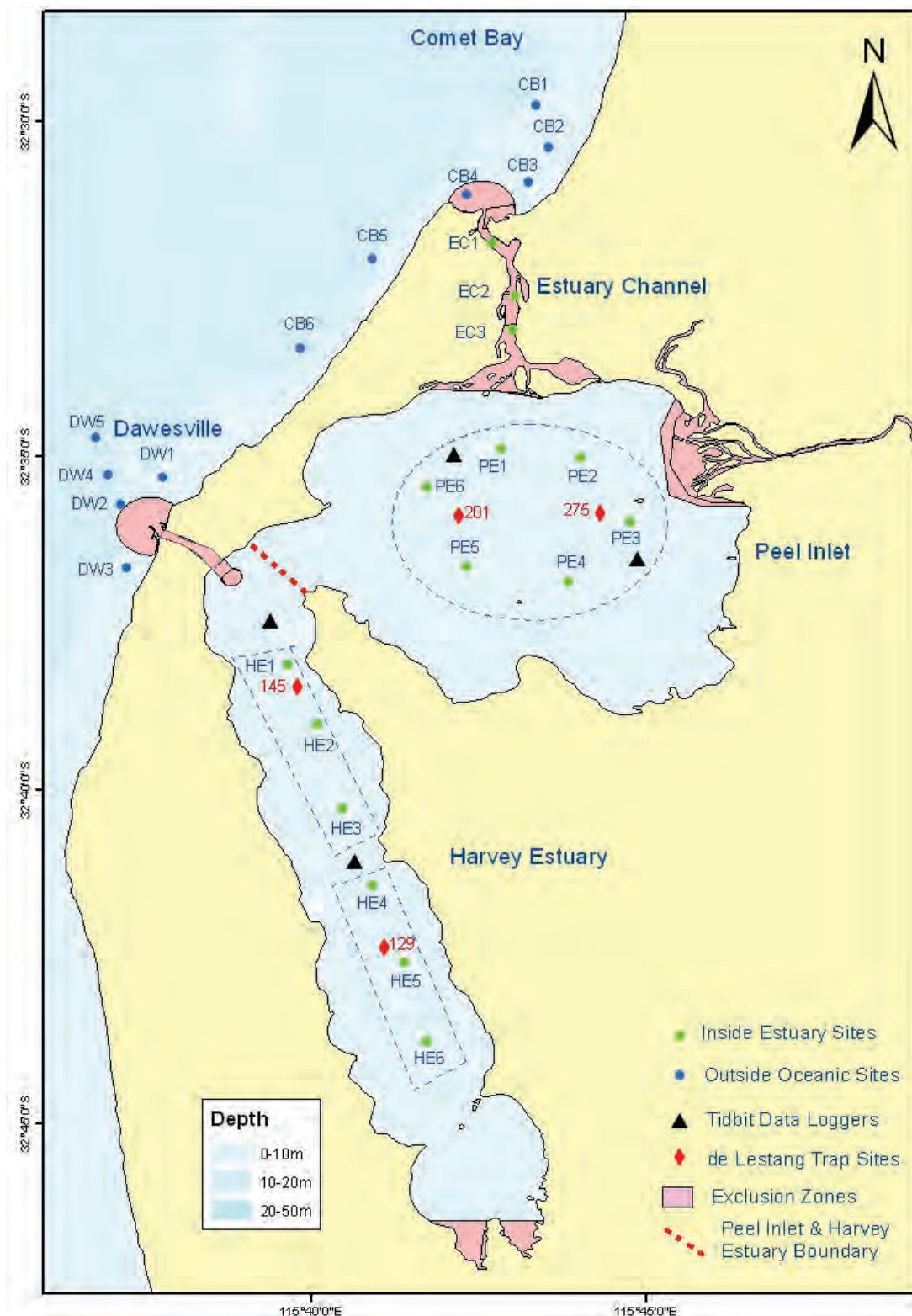


Figure 8.3. Map of the PHE detailing fisheries-independent research sampling sites inside and outside the estuary and de Lestang (2002) trap sites. Data from current sampling sites compared to data from de Lestang (2002) sites are indicated by the broken blue line. Sites PE1-6 and 201/275 were compared for Peel region; sites HE1-3 and 145 were compared for Dawesville Channel-Harvey region; sites HE4-6 and 129 were compared for Deep-Harvey region.

Table 8.3. Research sampling methods, periods and sites in the PHE region. (Refer to Figure 8.3 for site code locations.)

Sampling method	Sampling period	Sites sampled
Trawl (~ 750 m)	Feb 2007 – Nov 2007	15 sites (All inside PHE sites)
Trawl (100 – 200 m)	Dec 2007 – Jan 2009	4 sites (EC1, EC2, EC3, HE1 only)
Trap	Jun 2007 – Nov 2007	5 sites (3 traps/site) (EC3, HE2, HE5, PE1, PE5 only)
Trap	Dec 2007 – ongoing*	15 sites (3 traps/site) (PE1-6, HE1-6, EC1-3)
Trap	Aug 2008 – Oct 2012	9 sites outside PHE (CB1-6, DW1-3) (5 traps / site)
Trap	Mar 2009 – Sep 2011	2 sites added outside PHE (DW4-5) (5 traps / site)

* Note that since 2013, monthly fishery-independent trap surveys have been undertaken only between June and November.



Figure 8.4. Hourglass research crab trap used in the fishery-independent monitoring surveys in the PHE (Photo credit: Chris Marsh [DoF]).

MSC Principle 2

MSC Principle 2 (P2) focuses on minimising environmental impact, such that fishing operations should be managed to maintain the structure, productivity, function and diversity of the ecosystem on which it depends (MSC 2013). This section has been divided into fishery impacts, management and information and monitoring. The first section provides an overview of current fishery issues, including a summary of the commercial fishery's Environmental Management System (EMS) and risk assessments that have been done as part of the MSC assessment process. Fishery and gear-specific impacts are addressed for each of the following components:

- Retained (non-target) species;
- Bycatch species;
- Endangered, threatened and protected (ETP) species; and
- Habitats.

Fishery impacts on the ecosystem have been assessed at the whole-of-operations level and include removals and other impacts collectively. The management and information and monitoring sections are divided into the commercial and recreational fishing sectors, as the majority of management and monitoring occurs at the fishery / sectoral level.

9. Fishery Impacts

9.1 Risk Assessments

9.1.1 Environmental Management System

An EMS is a formal, documented process used for addressing issues or risks affecting the environmental and social sustainability of a human activity and is based on the philosophy of continual improvement. The benefit for commercial fisheries in developing an EMS is that it provides an organised, documented and coordinated approach to improving and demonstrating the environmental performance of the industry.

The WCEMF (Area 2) EMS (MLFA n.d.) was developed voluntarily by members of the MLFA with the assistance of Ocean Watch Australia's SeaNet Program and WAFIC. This EMS was based on continuous improvement through the identification of risks and impacts that will be dealt with via a responsible action plan that is reviewed regularly. The qualitative risk assessment process conducted as part of the EMS process was used to identify issues with current fishing practices that pose a threat to the long-term sustainability of the fishery. While qualitative in nature, the risk assessment identified a number of environmental, economic and social impacts that occur as a result of fishers commercial activities. These risks were then prioritised to enable fishers to address issues within the fishery (MLFA n.d.).

9.1.2 Productivity Susceptibility Analysis (PSA)

In December 2014, an internal risk assessment was conducted on target, retained, bycatch and ETP species for the WCEMF Area 2 using PSA methodology. Included species were identified from commercial CAES returns, research monitoring and fishing surveys from the WCEMF Area 2 net and trap sectors and the blue swimmer crab recreational fishery.

Twenty-eight species / groups were assessed for the WCEMF Area 2 net fishing sector, which targets sea mullet, and 20 species / groups were assessed for the WCEMF Area 2 trap sector and the recreational drop net and scoop net sectors, which target blue swimmer crabs. All species were assessed as a low risk, with the exception of cobbler and Perth herring (*Nematalosa vlaminghi*) in the WCEMF Area 2 net fishing sector. The higher scores for these two species were a consequence of their life history characteristics, such as a restricted distribution within estuarine environments. Due to the higher vulnerability of these species to fishing impacts, they have been incorporated in the harvest strategy for the finfish resources in the PHE, with species-specific reference points and control rules in place (see DoF 2015a).

The PSA tables generated as part of this risk assessment process are provided in Appendix B, with associated risk ratings provided throughout this section, where relevant.

9.1.3 Scale Intensity Consequence Analysis (SICA) and Consequence Spatial Analysis (CSA)

Despite the amount of monitoring undertaken in the PHE as part of Ramsar and other requirements, there is limited information on the distribution of benthic or nearshore habitats in the PHE. There are three main benthic habitats in the estuary: sand, seagrass and

macroalgae, with the biomass and distribution of these habitats highly variable, both seasonally and between years. In addition, the location of commercial fishing activities relative to benthic habitats in the estuary is relatively unknown, as all commercial fishing activities occur within one reporting block on the catch and effort (CAES) returns. (Note some distributional fishing information is available from blue swimmer crab commercial monitoring undertaken annually by the Department's research division.)

Due to the lack of quantitative information, in January 2015, an internal risk assessment was conducted on benthic habitats for the WCEMF Area 2 using both SICA and CSA methodologies. Each fishing method, i.e. gill nets, haul nets, crab traps, drop nets and scoop nets, were assessed separately in the SICA and CSA analyses (see Appendix B for more information on risk assessment methodologies).

Using the SICA methodology, all fishing methods in the PHE scored a Consequence Category of 1, which has an MSC equivalent score of 100 %. Using the CSA methodology, both haul and gillnetting scored 70 %, i.e. medium risks, while crab trapping, drop and scoop netting all scored > 80 %, i.e. low risks.

9.2 Retained (Non-Target) Species

This section includes all species that are retained by commercial fishers in the commercial WCEMF (Area 2) and recreational blue swimmer crab fishers in the PHE, in addition to the 'target' (P1) species. Main retained species have been identified as those species which have comprised more than 5 % of the average total catch (for each fishing sector / method) in the last five years.

9.2.1 Commercial Net Fishery

The commercial net fishery is a multi-species fishery and in addition to sea mullet, fishers retain a range of other nearshore and estuarine finfish species, in particular yelloweye mullet, yellowfin whiting (also referred to as 'western sand whiting'), tailor, cobbler and Australian herring (Table 9.1). The majority of catch is taken using haul nets and visually targeting schools of fish, with fishers employing different net lengths and mesh sizes to catch fish of different species or sizes throughout the estuary based on species availability and market demand. Sea mullet generally comprises around 50 % of the total annual finfish catch, with other main retained species combined comprising ~ 40 % of the total catch (Table 9.2). In recent years there has been a strong shift to catching fish for human consumption rather than bait, with catches of mullet declining at times in preference to other, more valuable species.

The status of various finfish suites in the waters of WA are assessed by monitoring indicator species (see DoF 2011 for details). Indicator species for estuarine finfish suite in the WCB, in which the PHE is located, are black bream, Perth herring and cobbler. As these species are considered to be estuarine-dependent and thus have an obligatory reliance on estuarine habitats for spawning, feeding and / or nursery areas, they are inherently more vulnerable to fishing impacts within estuaries. The stock status of these indicator species are assessed through Level 2 assessments based on trends in catch and effort (Smith *et al.* 2014).

As outlined in the harvest strategy for the finfish resources of the PHE (DoF 2015a), appropriate performance indicators, reference levels and control rules have been developed for all retained species to satisfy the long-term management objective of maintaining spawning stock biomass of each such species at a level where the main factor affecting recruitment is the environment. Resource-specific reference levels have been identified for yelloweye mullet, yellowfin whiting, Australian herring, tailor, cobbler and Perth herring in the PHE, as they comprise a significant proportion (i.e. > 5 %) of the total annual commercial catch and / or have life history characteristics that make them inherently vulnerable to fishing impacts. For each species, annual commercial catches and / or catch rates are used as the primary performance indicator for monitoring the status of these resources in the PHE and ensuring that these remain within historical levels (generally using the same reference period as sea mullet, i.e. 1 January 2000 – 31 December 2011). The target catch / catch rate levels are as follows:

- Yelloweye mullet: annual commercial catch is < 46 tonnes;
- Yellowfin whiting: annual commercial catch is < 12 tonnes;
- Australian herring: annual commercial catch is < 9 tonnes;
- Tailor: annual commercial catch is < 9 tonnes;
- Cobbler: annual catch rate of cobbler is > 6 kg / fishing day and annual commercial catch is < 9 tonnes;
- Perth herring: annual commercial catch of Perth herring is < 2.7 tonnes; and
- All other retained species: annual commercial catch of each other retained species is < 5 % of the total retained catch.

In addition, fishing impacts on retained species are also assessed using a risk-based approach. As such, each species also has risk-based reference levels set to differentiate acceptable (target) and unacceptable (limit) risk levels.

Table 9.1. Retained species catches (kg) for the WCEMF Area 2 (haul and gillnet sectors) for 2004 – 2013. Dark blue shading indicates target (P1) species and light blue shading indicates main retained species (i.e. > 5 % total retained catch based on the average catch for 2009 – 2013);

Common Name	Annual Catch (kg)																			
	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
	GN	HN	GN	HN	GN	HN	GN	HN	GN	HN	GN	HN	GN	HN	GN	HN	GN	HN	GN	HN
Mullet, Sea	15494	46474	11336	37717	6272	46502	18113	44029	12201	38039	23501	39988	16568	53730	18230	30112	17067	38664	11746	56034
Mullet, Yellow Eye (Pilch)	17687	28389	14962	17794	7871	19041	11021	19725	10496	14852	12152	13700	13200	11117	7222	7392	10717	9841	3249	13347
Whiting, Yellowfin	3404	5615	6369	5794	5263	3834	3742	1253	5941	4350	5852	3515	3312	7185	4303	3828	4740	5678	5992	7962
Herring, Australian	2047	1761	3091	6248	2112	6900	1734	6590	1584	4829	4648	4641	2242	2834	1508	4650	970	2207	1600	1208
Tailor		1159	426	1114	242	523	884	567	227	810	3531	2642	1406	2744	3756	1684	4905	3286	8234	4434
Cobbler	1270		1646	1214	542	21	481	17	6273	365	7343	1892	3864	1554	7213	210	3758	1456	1745	9
Whiting, King George	1349	207	1159	1247	1079	874	711	61	2182	1600	1301	497	2860	2278	1796	1792	128	57	21	5
Herring, Perth	1034	200	1107	1570	308	803	105	115	714		1567		38		277	79	896	82	1421	104
Trevallies, General			65	13		79	100	143	114	398	389	984	249	1281	413	1156	858	693	1109	704
Whiting, General/Sand									67		66		38	2163		3196	30	21	594	473
Trevally, Skipjack/Silver								100		186		476		1630				20		
Salmon, Australian						4	178	60		450	424									
Garfish, Southern Sea	52	200	70	217	45							19	1	261						
Scad, Yellowtail																450				
Bream, Black						10	5								3		3	50	223	43
Flatheads, General									10	20	30	2	3		22	44	1	2	11	2
Skates, General				86		14														
Common Silverbiddy			6						1				13		3				50	23
Leatherjackets, General										85										
Octopus, General						48		7												

Flounders, General																	10			
Mulloway																	8			
Other Fish Varieties						2					6									
Herrings, Giant																	3	3		
Trumpeters/ Grunters, General									6											
Squids, General					1															
Total (kg)	42337	84005	40237	73014	23734	78654	37074	72667	39812	65984	60804	68362	43800	86777	44743	54596	44073	62057	36016	84351
Annual Total (kg)	126 342		113 251		102 388		109 741		105 796		129 166		130 577		99 339		106 130		120 367	

Table 9.2. Per cent (%) of the total average catch for each species by net type and combined overall catch over the five-year period from 2009 through 2013.

Common Name	Percent Of Catch		
	GN	HN	Total Catch
Mullet, Sea	37.97 %	61.36 %	52.19 %
Mullet, Yellow Eye (Pilch)	20.28 %	15.55 %	17.41 %
Whiting, Yellowfin	10.55 %	7.91 %	8.94 %
Herring, Australian	4.78 %	4.36 %	4.53 %
Tailor	9.52 %	4.15 %	6.25 %
Cobbler	10.43 %	1.44 %	4.96 %
Whiting, King George	2.66 %	1.30 %	1.83 %
Herring, Perth	1.83 %	0.07 %	0.76 %
Trevallies, General	1.32 %	1.35 %	1.34 %
Whiting, General/Sand	0.32 %	1.64 %	1.12 %
Trevally, Skipjack/Silver	0.00 %	0.60 %	0.36 %
Salmon, Australian	0.18 %	0.00 %	0.07 %
Garfish, Southern Sea	0.00 %	0.08 %	0.05 %
Scad, Yellowtail	0.00 %	0.13 %	0.08 %
Bream, Black	0.10 %	0.03 %	0.05 %
Flatheads, General	0.03 %	0.01 %	0.02 %
Skates, General	0.00 %	0.00 %	0.00 %
Common Silverbiddy	0.03 %	0.01 %	0.02 %
Leatherjackets, General	0.00 %	0.00 %	0.00 %
Octopus, General	0.00 %	0.00 %	0.00 %
Flounders, General	0.00 %	0.00 %	0.00 %
Mulloway	0.00 %	0.00 %	0.00 %
Other Fish Varieties	0.00 %	0.00 %	0.00 %
Herrings, Giant	0.00 %	0.00 %	0.00 %
Trumpeters/Grunters, General	0.00 %	0.00 %	0.00 %
Squids, General	0.00 %	0.00 %	0.00 %

9.2.1.1 Assessment Outcomes

9.2.1.1.1 Yelloweye mullet

2014 PSA Risk Rating: (1.93) Low

Yelloweye mullet inhabit coastal waters and estuaries as well as riverine environments, with a single stock in estuaries and marine waters in WA that is targeted by both commercial and recreational fishers.

Since commercial fishers in the PHE converted from gillnets to using traps for targeting blue swimmer crabs in 2000, annual yelloweye mullet landings have ranged between 46 t in 2001 to 15 t in 2011. In 2013, 17 t of yelloweye mullet was retained in the WCEMF Area 2, which constituted ~ 14 % of the total retained fishfish catch.

9.2.1.1.2 Yellowfin whiting

2014 PSA Risk Rating: (2.18) Low

Yellowfin whiting are endemic to Australia and inhabit deeper waters in sheltered, marine nearshore environments and estuaries over bare sand (Smallwood *et al.* 2013).

Commercial catches of yellowfin whiting in the PHE since 2000 have ranged between 5 t in 2001 and 14 t in 2013. The 14 t of yellowfin whiting landed in 2013 (comprising ~ 12 % of the total retained finfish catch) was the fourth largest catch of this species on record in the fishery, with 15 t recorded in both 1996 and 1997, and a peak of 19 t in 1980. Although it is clear that the stock has previously sustained catches at the current level, an investigation has been triggered to determine the reasons for the breach of the threshold level in 2013 (i.e. catch > 15 % above the target level of 12 t).

9.2.1.1.3 Australian herring

2014 PSA Risk Rating: (2.18) Low

Australian herring is an indicator species used to monitor the status of nearshore finfish resources in the WCB (and the South Coast Bioregion). They are endemic to southern Australia, and are found in pelagic, nearshore coastal marine waters, estuaries and bays (Smallwood *et al.* 2013). There is a single stock over the full range of the species distribution (Ayvazian *et al.* 2004; Moore & Chaplin 2013).

Australian herring is one of the most frequently caught recreational species and is also targeted by multiple commercial fisheries, which use shore-based or nearshore netting methods. Since the 1970s, between 80 and 90 % of total commercial landings of Australian herring have been landed in the South Coast Bioregion, with only 10 – 20 % taken in the WCB. Within the WCB, commercial catches within the PHE have traditionally been < 1 % of the state landings.

Declining catch rates have been observed throughout the state, which has been attributed to overfishing and environmental factors, such as fluctuations in the strength of the Leeuwin Current (Smith *et al.* 2013; Smith & Brown 2014) and a number of management measures have recently been implemented to reduce the commercial and recreational catch of this species. Australian herring catches in the WCEMF Area 2 have comprised approximately 5 % of the total finfish catch in the WCEMF Area 2 net fishery since 2000, with ~ 3 t (2 % of the total retained catch) retained in 2013.

9.2.1.1.4 Tailor

2014 PSA Risk Rating: (2.38) Low

In WA, tailor is found in coastal waters from Onslow to Esperance and is likely to constitute a single stock over this range. Incomplete records prior to 1976 suggest the total WA annual commercial catch of tailor probably peaked in 1965 at approximately 90 t. Since 1976, annual landings have fluctuated between 19 and 59 t but with an overall stable trend. In the WCB, total commercial landings of tailor declined from 28 t in 1976 to reach an historical minimum of 2 t in 2008. Subsequent landings have increased slightly, with 14 t of tailor commercially landed in the WCB in 2013. The majority (89 %) of WCB landings in 2013 were taken in the PHE (13 t retained in 2013; Smith *et al.* 2014).

As the 2013 catch of tailor in the PHE was outside the threshold level (i.e. > 15 % above the target level of 9 tonnes) an investigation was triggered to determine the reasons for the variation. The increase in catches over the past few years is consistent with a high index of juvenile abundance observed in the Swan River during 2010 – 2011 (DoF unpubl. data). Therefore, no management action has been taken but catches of this species will continue to be closely monitored over the upcoming years to assess if there is any increase in risk to the stock.

9.2.1.1.5 Cobbler

2014 PSA Risk Rating: (2.89) Medium

Commercial targeting of cobbler is restricted to estuaries and each estuary in WA hosts a discrete stock of cobbler. Since 2000, only 5 % of the total cobbler catch in the state has been caught in the WCB, with virtually all of these landings in the PHE.

In the PHE, annual commercial landings during the 1950s, 1960s and 1970s were frequently > 100 t however, annual landings have fluctuated from 3 to 233 t between 1980 and 1996. Since 1996, annual landings have ranged from < 1 to 10 t. In 2013, 2 t of cobbler was caught in the WCEMF Area 2 (Smith *et al.* 2014).

Commercial gillnet catch rates suggest fluctuating availability of cobbler in the PHE since 1990. As assessed in 2014 (PHE only), the long-term trend from 1990 to 2013 was stable (i.e. non-directional; Figure 9.1), and the breeding stock was assessed to be at an adequate level (Smith *et al.* 2014).

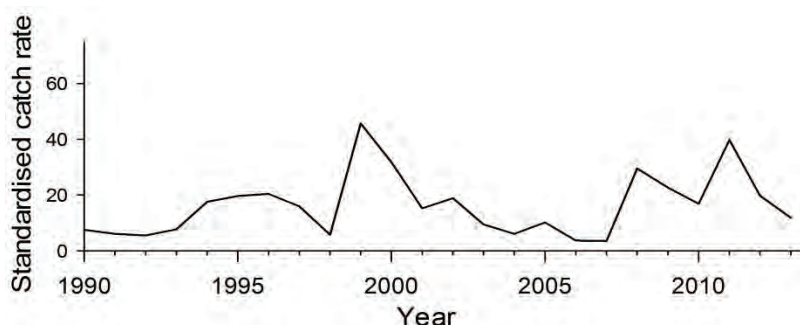


Figure 9.1. Annual commercial gillnet catch rate (kg per fishing day in July – September) of cobbler in the PHE 1990 – 2013 (Smith *et al.* 2014)

9.2.1.1.6 Perth herring

2014 PSA Risk Rating: (2.73) Medium

Perth herring (*Nematalosa vlaminghi*) is endemic to the WCB and constitutes a single stock over this range. Perth herring was historically assessed via commercial catch rate trends in the Swan-Canning Estuary, until cessation of fishing for this species in 2007. Catch rates in the Swan-Canning Estuary suggested a major decline in the availability of Perth herring after 1980, and Swan-Canning catch rates are assumed to be representative of regional availability. Limited fishery-independent evidence suggests regional abundance remains relatively low compared to historical levels however, insufficient information is available to assess current stock status (Smith *et al.* 2014).

There have been minor quantities of Perth herring taken since 2007, primarily from the PHE, although catches of this species in recent years has remained very low (see Table 9.1). In 2013, the WCEMF Area 2 net fishery retained ~ 1.5 t of Perth herring.

9.2.2 Commercial Trap Fishery

Commercial trap fishers are permitted to retain a number of species, but in practice, the only species retained other than blue swimmer crabs has been octopus (Table 9.3). This is mainly due to the highly selective design of the crab traps, which minimised the capture of other species. Within the last 10 years, blue swimmer crabs have consistently comprised over 99 % of the total catch annually.

Table 9.3. All retained species (t) for the WCEMF Area 2 (trap sector) 2004/05 – 2013/14. Dark blue indicates target (P1) species. Octopus catches reflect ‘live weight’ catch reports.

Species	Catch (tonnes)									
	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14
Blue swimmer crab	78.67	72.38	103.69	90.19	48.20	63.91	62.08	81.19	102.34	104.53
Octopus	0.00	0.06	0.13	0.06	0.01	0.04	0.03	0.02	0.01	0.08
Total	78.67	72.44	103.83	90.25	48.22	63.95	62.12	81.21	102.37	104.61

9.2.2.1 Bait Usage

Sea mullet and yelloweye mullet are the main bait species used by trap fishers in the WCEMF Area 2. Both species are sourced locally from around Perth or are caught by the fishers in the PHE while fishing under their netting licences (see net-fishery impacts above). Generally 300 grams of bait (mixed species) is used per trap, resulting in a conversion rate⁵ of 0.2 – 0.3 depending on the season’s catch and effort (Table 9.4).

⁵ The conversion rate indicates the amount of bait used (kg) to catch one kg of blue swimmer crabs.

Table 9.4. Summary of bait usage in the WCEMF Area 2 (trap sector). The number of traps per day is an average of the number of traps used per year.

Year	Total Days Fished	Total No. of Traps / Year	Total Catch (kg)	Bait Type	Amount of Bait used per Trap (g)	Total Bait used (kg)	Conversion Rate
2006/07	1657	69594	103692	Sea mullet Yelloweye mullet	300	20878	0.2
2007/08	1396	58632	90191	Sea mullet Yelloweye mullet	300	17590	0.2
2008/09	1233	51786	48203	Sea mullet Yelloweye mullet	300	15536	0.3
2009/10	1183	49686	63907	Sea mullet Yelloweye mullet	300	14906	0.2
2010/11	1270	53340	62084	Sea mullet Yelloweye mullet	300	16002	0.3
2011/12	1165	48930	81190	Sea mullet Yelloweye mullet	300	14679	0.2
2012/13	1517	63714	102356	Sea mullet Yelloweye mullet	300	19114	0.2

9.2.2.2 Assessment Outcomes

9.2.2.2.1 Octopus

2014 PSA Risk Rating: (1.49) Low

Octopus cf. tetricus is endemic to WA and is distributed from Shark Bay to Esperance (Edgar 1997). They are found in cryptic habitats, particularly inshore limestone reefs to about 60 m depth (Wadley & Dunning 1998) and are highly fecund (Joll 1976). Catches of octopus in the WCEMF Area 2 trap fishery are minor, with generally less than 100 kg retained annually.

9.2.3 Recreational Drop Net Fishery

Blue swimmer crabs are the target species for over 90 % of the recreational fishers in the PHE (Malseed & Sumner 2001). Fishers actively target blue swimmer crabs with gear designed specifically to catch this species, with the majority of fishing activities is undertaken over the summer months (November through April; Malseed & Sumner 2001). Catch of other species during recreational blue swimmer crab fishing is minimal.

Based on data collected as part of recreational blue swimmer crab surveys conducted in 1998/99 and 2007/08, non-target species retained by recreational crab fishers using drop nets

(reported as ‘crab nets’ in survey data) included a number of finfish and invertebrates (Table 9.5). None of the other retained species reported during these surveys comprised more than 5 % of the average total catch. Retained species also included Australian herring, tailor and whiting. However, the data has not been independently validated and may not be representative of the suite of species caught in the fishery.

The majority of these species are also captured and retained in commercial net fisheries within and around the estuary, including the WCEMF Area 2 net fishery (see Table 9.1 above) and a number of beach-based net fisheries, such as the West Coast Beach Bait Managed Fishery and the West Coast Nearshore Net Fishery; however, they are not considered to be ‘target’ species by any fisheries within the region. Some of these species, i.e. Australian herring and tailor, are also considered to be key recreational species for the WCB (Ryan *et al.* 2013).

Table 9.5. Total retained and discarded species (by number) by recreational blue swimmer crab fishers using drop nets in 1998 – 1999 and 2007 – 2008. Blue shading indicates target (P1) species. Per cent (%) total catch calculated across all four surveys combined.

Species Name	Number Retained				Number Discarded				% Total Catch
	1998	1999	2007	2008	1998	1999	2007	2008	
Blue swimmer crab	5313	15829	866	7780	6474	19288	2417	9676	99.49
Australian Herring	1	69	0	49	0	14	0	2	0.20
Tailor	0	10	5	13	0	5	10	27	0.10
General/Sand Whiting	0	11	0	1	0	0	0	5	0.03
King George Whiting	0	6	0	4	0	0	0	0	0.01
School Southern/Silver Whiting	0	0	1	0	0	0	0	0	0.00
Western School Whiting	0	1	0	0	7	0	0	0	0.01
Western Rock Lobster	0	0	4	0	0	0	0	0	0.01
Skipjack/Silver Trevally	0	0	1	0	0	0	0	0	0.00
Six Lined Trumpeter (Striped Trumpeter)	0	0	0	2	0	0	0	0	0.00
Common blowfish	12	0	0	0	1	9	0	11	0.05
Mussels	18	30	0	0	0	0	0	0	0.07
Western Buffalo Bream	1	0	0	0	0	0	0	0	0.00
Octopus, general	0	1	0	0	0	0	0	0	0.00
Trumpeters/Grunters, general	0	2	0	0	0	0	0	0	0.00
Brown-Spotted Wrasse	0	1	0	0	0	0	0	0	0.00
Rough leatherjacket	0	0	0	0	2	0	0	3	0.01
Pufferfish, toadfish and tobies	0	0	0	0	0	0	5	0	0.01
Stingray, general	0	0	0	0	0	0	0	1	0.00
Wrasses/Gropers, general	0	0	0	0	0	0	0	5	0.01

9.2.3.1 Bait Usage

Recreational fishers use a variety of bait in drop nets. Information on bait use in drop nets is available from a survey conducted in the PHE in December 2014. This survey was conducted by the Department in order to collect information on the type of bait used, how much bait is used and where bait is obtained from for recreational fishers using drop nets to target blue swimmer crabs in the PHE. A total of 19 surveys were completed over a two week period, with respondents setting drop nets from a variety of locations around the estuary, including boats, boardwalks, bridges and from the shore. A number of bait species were reported (Table 9.6), with sea mullet, chicken and lamb the main bait species used.

All sea mullet and tuna used was purchased from a bait shop, with all other fish species caught by the fishers either within the PHE (e.g. tailor, bream, trumpeter and crab) or elsewhere (e.g. dhufish and silver trevally). All meat products, e.g. chicken, lamb and spleen, were purchased from supermarkets.

Table 9.6. Sample of bait species and amount used (number) by recreational drop net fishers in the PHE. 'U' indicates reported species, but unknown number used.

Bait Species	Bait Type	Number used				Total
		Boat	Bridge	Shore	Boardwalk	
Sea mullet	Whole	23			22	45
Chicken	Carcass		7			7
	Wing		4	4	8	16
	Neck		9			9
	Pieces				U	U
Tailor	Head	15				15
Lamb	Neck	11				11
	Pieces		6			6
	Chops		4			4
Tuna	Head	6				6
Bream	Head				4	4
Dhufish	-	4				4
Silver trevally	Whole				3	3
Trumpeter	Whole		2			2
Crab	Whole		1			1
Sand whiting	Pieces				U	U
Spleen	-	U				U
Total		59	33	4	37	133

9.2.3.2 Assessment Outcomes

9.2.3.3 All Retained Species

2014 PSA Risk Rating: Low

The non-target species retained in the blue swimmer crab drop net recreational fishery are distributed throughout south-western Australia in both nearshore and estuarine environments, and none are restricted to the PHE (Smallwood *et al.* 2013).

The 2014 PSA (Appendix B) found the risk rating for all retained species to be low based on the wide distribution of each species, high productivity (either early reproduction and / or high fecundity) and medium susceptibility to drop nets (attracted to bait but are able to escape easily). This low vulnerability, combined with low catches, strongly indicates that the impacts of the blue swimmer crab drop net fishery on other retained species is likely to be minimal and well within biologically-based limits.

9.2.4 Recreational Scoop Net Fishery

The scoop nets used by fishers are used in a very targeted manner to catch blue swimmer crabs, with very little catch of other species. Based on data collected as part of recreational blue swimmer crab surveys conducted in 1998/99 and 2007/08, non-target species retained by recreational crab fishers using scoop nets (over these two sample periods) included a number of finfish and invertebrates (Table 9.7). None of the other retained species reported during these surveys comprised more than 5 % of the average total catch. The primary retained species included Australian herring, tailor and mussels. However, the data has not been independently validated and may not be representative of the suite of species caught in the fishery.

The majority of these species are also captured and retained in commercial net fisheries within and around the estuary, including the WCEMF Area 2 net fishery (see Table 9.1 above) and a number of beach-based net fisheries; however, they are not considered to be 'target' species by any fisheries within the region. Australian herring and tailor are also considered to be key recreational species for the WCB (Ryan *et al.* 2013).

Table 9.7. Total retained and discarded species (by number) by recreational blue swimmer crab fishers using scoop nets in 1998 – 1999 and 2007 – 2008. Blue shading indicates target (P1) species. Per cent (%) total catch calculated across all four surveys combined.

Species Name	Number Retained				Number Discarded				% Total Catch
	1998	1999	2007	2008	1998	1999	2007	2008	
Blue swimmer crab	304	696	24	959	371	627	290	1243	97.3
Australian herring	0	26	0	45	0	0	0	0	1.5
Mussels	18	0	0	0	0	0	0	0	0.4
Tailor	0	0	1	0	0	0	0	0	0.0
Common blowfish	0	0	0	0	0	0	0	34	0.7

9.2.4.1 Risk Assessment Outcomes

9.2.4.2 All Retained Species

2014 PSA Risk Rating: Low

The non-target species retained in the blue swimmer crab scoop net recreational fishery are distributed throughout south-western Australia in both nearshore and estuarine environments, and none are restricted to the PHE (Smallwood *et al.* 2013).

The 2014 PSA (Appendix B) found the risk rating for all retained species to be low based on the wide distribution of each species, high productivity (either early reproduction and/or high fecundity) and medium susceptibility to drop nets (attracted to bait but are able to escape easily). This low vulnerability, combined with the very low catches, strongly indicates that the impacts of the blue swimmer crab scoop net fishery on other retained species is likely to be minimal and well within biologically-based limits.

9.3 Bycatch

9.3.1 Commercial Net Fishery

The haul nets used by the commercial finfish net fishery are deployed in a targeted manner, so that few non-target species are captured. In addition, the mesh sizes used (typically 2 – 4 inches, depending on net type and species / size targeted) allow for the escape of any smaller or unwanted individuals. Thus, virtually all captured fish are retained and minimal discarding occurs. Any discarded fish are returned to the water (alive) as the nets are being hauled or as soon as possible after landing. Fishers are also able to drop the nets completely to allow fish to escape, should a large number of unwanted fish be enclosed in the net.

For example, during a single fishing trip in December 2014 in which three shots were hauled, 230 kg of sea mullet were retained, along with a small amount (< 5 kg) of yelloweye mullet. During these three shots, the only discarded catch was two blue swimmer crabs (not permitted to be retained by licensees when fishing with a net in the PHE), which had become entangled in the fishing net. These crabs were returned to the water alive.

In order to obtain information on bycatch species and quantities in the WCEMF Area 2 net sector, a pilot bycatch observer project was undertaken in March 2015. The aims of this project were:

- To assess the level of bycatch in the PHE (haul net) fishery, including:
 - Catch [no.] of discarded species;
 - Proportion of retained and discard species in the total catch; and
- To validate reporting of ETPs interactions (both direct and indirect) by commercial fishers in the haul net fishery.

Two methods were used to gather information on the catch composition of the haul nets used in WCEMF (Area 2) net fishery:

- On-board observer monitoring of bycatch⁶; and
- Sampling of landed (retained) catch on shore.

As the observer program was reliant on the voluntary participation of commercial fishers, the sampling regime was opportunistic and the effects of seasonality, location and gear type were not assessed.

The fishing activities of one commercial fisher were observed resulting in bycatch information for three (3) fishing days, with one net shot each day. The target species, sea mullet, comprised the majority of the catch for each shot, with very low amounts of byproduct (other retained species) and discarded bycatch (Table 9.8).

Based on the average weight for these species as estimated during statewide recreational boat ramp surveys in 2011/12 (Ryan *et al.* 2013), the discarded bycatch comprised < 1 % of the total catch during these trips (Table 9.9).

Table 9.8. Observed haul net catch in the WCEMF Area 2 in March 2015

Date	Mesh Size (in.)	Target Species		Other Retained Species		Discarded Bycatch		
		Species	Catch (kg)	Species	Catch (no.)	Species	Catch (no.)	Return Status
2 / 3	3.5	Sea mullet	600	–	–	–	–	–
23 / 3	2.5	Sea mullet	286	Yellowfin whiting	6	Blue swimmer crab	1	Alive
30 / 3	3 – 3.5	Sea mullet	600	–	–	Western striped trumpeter	1	Dead

Table 9.9. Estimated total weight (kg) and proportion (%) of total catch comprised by each captured species during three observer trips

Species	Scientific Name	Estimated Average Weight (kg)	No. Caught in Haul Nets	Estimated Total Weight (kg)	% of Total Catch
Sea mullet	<i>Mugil cephalus</i>	NA	NA	1486	99.9
Yellowfin whiting	<i>Sillago schomburgkii</i>	0.096	6	0.576	< 0.01
Blue swimmer crab	<i>Portunus armatus</i>	0.250	1	0.250	< 0.01
Western striped trumpeter	<i>Pelates octolineatus</i>	0.083	1	0.083	< 0.01
Total Catch (kg):				1486.91	

⁶ 'Bycatch' was defined as animals caught in the nets that were not retained for sale or use, e.g. as bait for crab potting. This includes individuals of marketable species (above or below the regulated size limits), non-marketable species and endangered, threatened and protected (ETP) species.

This project provided valuable information on the amount and composition of bycatch in the WCEMF Area 2 (haul) net sector. The need and feasibility of continued sampling is currently being explored by the Department including the option of expanding this project to include gill netting activities, which primarily occur of the winter months.

9.3.1.1 Risk Assessment Outcomes

9.3.1.1.1 All Bycatch Species

2014 PSA Risk Rating: Low

As the 2014 PSA was conducted prior to the pilot bycatch sampling project, likely bycatch species were identified based on those species that have been reported as bycatch in the trap fishing sector (i.e. trumpeters/grunters, blowfish [‘weeping toadfish’, *T. pleurogrammus*], and jellyfish) as well as blue swimmer crabs, which fishers are not permitted to retain when fishing with nets in the PHE. These species are generally widely distributed throughout southwest WA and are highly productive.

Very small amounts of these species were believed to be captured in the fishing nets used, and where they are captured, they are generally released from the net or returned alive. Thus, it is highly likely they are within biologically-based limits.

9.3.2 Commercial Trap Fishery

The shift from using nets to traps to target blue swimmer crabs has resulted in a substantial reduction in bycatch from dedicated crab fishing. The traps used in the WCEMF Area 2 are purpose-designed to minimise the capture of non-target species and are therefore an inefficient way to capture fish, the majority of which are able to escape through the entrance gaps when the trap is soaking or being hauled (Johnston *et al.* 2014b).

Very little bycatch has been recorded in the trap fishery from on-board research monitoring (Table 9.10). The main bycatch species recorded over the past six years was blowfish.

Table 9.10. Bycatch species and catch observed in the PHE (trap) fishery for blue swimmer crabs during on-board catch monitoring conducted between July 2007 and December 2013. *Total number is an estimate for the entire period (2007 – 2013) based on observed catches per trap.

Common name	Species name	*Total Number	Total Number Per Trap
Weeping toadfish (common blowfish)	<i>Torquigener pleurogramma</i>	500	0 to 15
Western striped grunter (trumpeter)	<i>Pelates octolineatus</i>	< 10	0 to 3
Common Sydney octopus, Gloomy octopus	<i>Octopus cf. tetricus</i>	1	1 only
Cobbler	<i>Cnidoglanis macrocephalus</i>	1	1 only
Four-lobed swimming crab	<i>Thalamita sima</i>	< 50	0 to 3
Mud crab	<i>Scylla</i> sp.	2	2 only

9.3.2.1 Risk Assessment Outcomes

9.3.2.1.1 All Bycatch Species

2014 PSA Risk Rating: Low

The bycatch species caught in the WCEMF Area 2 trap fishery, e.g. blowfish, trumpeters/grunters, and other crabs, are generally widely distributed across the south west coast of WA and are highly productive.

Very few bycatch species are encountered in crab traps, with the exception of blowfish. In WA, this species is found along the south-west coast in the ocean and saline waters of estuaries. Blowfish have increased in abundance within the PHE since the opening of the Dawesville Channel and have expanded their distribution within the PHE further south into the Harvey Estuary (Young & Potter 2003).

9.3.3 Recreational Drop Net Fishery

Based on data collected as part of recreational blue swimmer crab surveys conducted in 1998/99 and 2007/08, the primary bycatch species discarded by recreational crab fishers using drop nets (over these two sample periods) included blowfish, tailor and Australian herring. However, the data has not been independently validated and may not be representative of the suite of species caught as bycatch in the fishery.

No bycatch species comprised more than 5 % of the total drop net catch reported during these surveys (see Table 9.5 above).

9.3.3.1 Risk Assessment Outcomes

9.3.3.1.1 All Bycatch Species

2014 PSA Risk Rating: Low

The bycatch species caught in the recreational blue swimmer crab drop net fishery, e.g. blowfish, tailor, and Australian herring, are generally widely distributed across the south west coast of WA. Very little bycatch is captured in the drop net fishery.

9.3.4 Recreational Scoop Net Fishery

Based on data collected as part of recreational blue swimmer crab surveys conducted in 1998/99 and 2007/08, the only bycatch species discarded by recreational crab fishers using scoop nets (over these two sample periods) was blowfish (see Table 9.7 above). However, the data has not been independently validated and may not be representative of the suite of species caught as bycatch in the fishery.

The amount of discarded blowfish did not comprised more than 5 % of the total scoop net catch reported during these surveys (see Table 9.5 above).

9.3.4.1 Risk Assessment Outcomes

9.3.4.1.1 All Bycatch Species

2014 PSA Risk Rating: Low

Very little bycatch is captured in the recreational blue swimmer crab drop net fishery. The only bycatch species reported in the fishery, e.g. blowfish, are generally widely distributed across the south west coast of WA. Additionally, blowfish have increased in abundance within the PHE since the opening of the Dawesville Channel and have expanded their distribution within the estuary during this time (Young & Potter 2003).

9.4 ETP Species

Endangered, threatened and protected⁷ (ETP) species in WA are protected by various international agreements and national and state legislation. International agreements include:

- *Convention on the Conservation of Migratory Species of Wild Animals 1979* (Bonn Convention);
- *The Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES);
- *The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974* (JAMBA)⁸;
- *The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986* (CAMBA)²;
- *The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007* (ROKAMBA)²; and
- Any other international agreement, or instrument made under other international agreements approved by the Environment Minister.

Primary national and Western Australian legislation include the Commonwealth EPBC Act, the FRMA and the *Western Australian Wildlife Conservation Act 1950*.

A number of ETP species occur within PHE, including dolphins, rays and migratory sea and shorebirds. The estuary is recognised as an internationally significant habitat for waterbirds and was listed as a Ramsar Wetland of International Importance⁹ in 1990 as part of the Peel-Yalgorup system (Hale & Butcher 2007). Tens of thousands of waterbirds gather in the estuary system each year, including both resident shorebirds that remain in Australia year round (e.g. the hooded plover and fairy tern) and migratory shorebirds that fly here from Siberia, North China and Alaska to escape the northern hemisphere winter. Over 80 species recorded (a number of which are listed on international migratory bird agreements [i.e.

⁷ Note that being on a protected species list does not automatically indicate that a species is either threatened or endangered

⁸ Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided at:
www.environment.gov.au/biodiversity/migratory/index.html

⁹ See [Ramsar Convention on Wetlands](http://www.ramsar.org.au/) website

JAMBA, CAMBA and ROKAMBA] and / or listed under the EPBC Act; see Appendix E; Hale & Butcher 2007).

There are four species that have been observed in the PHE that have not been recorded in any other part of the Peel-Yalgorup Ramsar site: Eastern Reef Egret, Artic Tern, Common Tern and Roseate Tern. These species are considered rare in the system because they are principally marine species (Hale & Butcher 2007).

Waterbird communities vary considerably throughout the year, with migratory species mainly present in the spring and summer (DAL 2002). Different species of waterbird use different habitats within the estuary. Large numbers of ducks arrive in summer attracted to the clay flats and silt jetties at the mouths of the Harvey and Murray Rivers (National Trust of Australia 1973), whereas shorebirds made use of the submerged flats along the eastern shore of the Harvey Estuary and south eastern shore of the Peel Inlet (National Trust of Australia 1973). The Creery Wetlands in the north-west support a large variety of waterbirds as do the samphire areas around Soldiers Cove. The abundance of shorebirds has been attributed to the lack of tidal variation and considerable area of shallow water (DAL 2002).

BirdLife Australia Shorebirds 2020 program undertakes annual bird counts in the PHE. Since 2009, annual bird counts have ranged from ~ 27 500 individuals to ~ 93 000 individuals, with approximately 28 000 birds counted in 2014. While bird numbers have been variable from year to year, the number of species recorded annually has remained more stable at between 50 and 65 species per year (Birdlife WA and PHCC, pers. comm.).

9.4.1 Commercial Net Fishery

Very few interactions with ETP species have been reported throughout the history of commercial fishing in the WCEMF AREA 2.

Estuarine birds have been known to interact with fishing nets, but no interactions have been reported in the WCEMF (Areas 1 and 2) since 2007. The WCEMF (Areas 1 and 2) reported five interactions with cormorants in 2006 and two interactions with cormorants in 2007 (DoF, unpublished data). This level of interactions is considered to pose a negligible risk to seabird populations within the PHE and is considered to be within national and international requirements for the protection of ETP species.

9.4.2 Commercial Trap Fishery

The crab traps used have little possibility of interacting with ETP species in the PHE, and no interactions have been reported throughout the history of the trap fishery.

9.4.3 Recreational Drop Net and Scoop Net Fisheries

There is no information currently available on the level of interactions with ETP species by recreational blue swimmer crab fishers in the PHE. However, given the fishing methods used are similar to those used by commercial fishers and the highly visible nature of fishing activities in the estuary, it is highly unlikely that the fishery is having an unacceptable impact.

There is the potential for shore-based scoop netters to indirectly impact sea and shore birds through trampling of important bird habitats while accessing fishing areas or undertaking fishing activities. However, a number of refuge areas exist for birds within the PHE and greater Ramsar area, as shore-based fishing effort is restricted to easily accessible areas around the estuary.

9.5 Habitats

The PHE is shallow, with a maximum depth of 2.5 m and an average depth of 0.5 m. There are two distinct parts of the estuary system, known as Peel Inlet and Harvey Estuary. The Peel Inlet has an area of approximately 75 km², and the elongated Harvey Estuary has an area of approximately 56 km². The Peel Inlet and the Harvey Estuary are joined by a narrow channel through the Point Grey Sill and the estuary is connected to the Indian Ocean via a natural entrance channel (the Mandurah Channel) in the northern Peel Inlet and an artificial entrance channel, the Dawesville Channel, which is located in the northern part of Harvey Estuary (see Figure 1.1). Both of these channels are kept open by regular dredging (Young 2000).

Peel Inlet is a wide, shallow saucer-shaped basin with a narrow channel to the sea. The inlet has a central portion, about two metres deep, surrounded by shallow, intertidal flats that are very wide on the eastern and southern sides and grade into supratidal samphire flats and marshes. A large proportion of the inlet contains water less than 0.5 m deep (see Figure 1.1). The eastern side of the inlet has wide intertidal mudflats and slopes gently upwards to wide samphire flats and marshes. The Murray and Serpentine Rivers flow into the north-eastern corner and have formed a large delta in this area (Wilson 1994).

The Harvey Estuary is an elongate barrier estuary formed behind dune ridges, discharging into the sea through the Peel Inlet. It has a central channel, also about two metres deep, bordered by shallow sand flats, principally along the eastern side where they grade into supratidal samphire flats and marshes. The Harvey River flows into the southern end of the estuary forming a prominent delta with wide mudflats (Wilson 1994).

The shallow waters of the PHE support extensive stands of macroalgae and seagrass. Fringing vegetation (salt marshes) occupy the upper part of the tidal zone from about mean water level to just above the extreme high water mark. The Estuary has three areas of extensive fringing vegetation: on either side of the Mandurah Channel, along the eastern side of Peel Inlet, and around the Harvey delta; only a narrow fringe of wetland exists elsewhere (Hale & Butcher 2007).

The PHE has suffered the effects of eutrophication for many decades, with these effects brought on by a combination of land clearing and the agricultural practices that followed (Humphries & Croft 1984; Humphries & Robinson 1995). The elevated nutrient levels in the estuary had led to two major problems in the different basins; toxic cyanobacteria *Nodularia* blooms were recorded in the Harvey Estuary, while excessive growth of green macroalgae in the Peel Inlet resulted in fouling of beaches, impacts on fisheries and offensive odours (McComb & Lukatelić 1995).

By the late 1960s, eutrophication had led to the loss of resident seagrasses, *Halophila* and *Ruppia*, and allowed the growth of the green macroalgae *Cladophora montagneana*. This resulted in *Chaetomorpha* as the dominant species of green macroalgae and to a lesser extent *Enteromorpha* and *Ulva* (Peel Inlet Management Authority 1994). From 1978 through 1992, regular blooms of toxic cyanobacteria (*Nodularia spumigena*) further escalated the nutrient pollution problem (Wilson *et al.* 1997). A number of strategies were developed to deal with the continuing problem of excess nutrients in the PHE (Peel Inlet Management Authority 1994), including the construction of the Dawesville Channel in 1994.

Prior to the opening of the Dawesville Channel, the most common seagrass was *Halophila ovalis*, which is more tolerant of low salinities and low light supply. After the channel opening, *Halophila* strands in the Peel Inlet consistently maintained high biomass in summer and autumn, and stands expanded to the northern half of the Harvey Estuary. *Halophila* was also recorded for the first time in deeper waters of the estuary, and patches of seagrass (*Heterozostera tasmanica*) were found near the eastern entrance of the Dawesville Channel (DAL 2002).

Results from recent seagrass and macroalgae monitoring in the PHE indicated that the greatest densities of macroalgal biomass were distributed in the south eastern region of the Peel Inlet and the south western shore of the Harvey Estuary. This differs greatly from post Channel distributions that covered larger portions of the eastern region and a smaller area to the north west of the Peel Inlet (Wilson *et al.* 1999). The percentage of total biomass for the Harvey Estuary in 2009 was much higher (41 %) than the surveys conducted just after the opening of the Dawesville Channel. Total biomass values for the Harvey Estuary were also significantly higher than immediate post-Channel data, while the Peel Inlet values were similar to those of past years (Pedretti *et al.* 2011).

The highest concentrations of macroalgal biomass for the Peel Inlet were located in the south-eastern regions above Austin Bay. In the Harvey Estuary, the highest macroalgal biomass was recorded at sites near the southern area, with smaller amounts extending north as far as Mealup Point (Figure 9.2). The dominant macroalgal group for the PHE was *Chlorophyta*, being an order of magnitude higher than the next major macroalgal group, *Rhodophyta*. Biomass distribution in the Peel Inlet was slightly higher than the Harvey Estuary for *Chlorophyta*, while *Rhodophyta* biomass was divided relatively evenly between the two systems (Pedretti *et al.* 2011).

The percentage of total seagrass as part of the total macroalgae and seagrass biomass in the PHE was higher from 1996 to 1999 than the 2009 spring/summer season. In 2009, the total seagrass biomass in the PHE was 3,718 t, comprising 68 % in the Peel Inlet and 32 % in the Harvey Estuary (Figure 9.3). The highest seagrass biomass was located on the eastern shoreline of the Harvey Estuary north of Mealup Point and in the Peel Inlet near Ward Point (Figure 3.41; Pedretti *et al.* 2011).

The dominant species for the estuary in 2009 was *Zostera* spp, followed by *Ruppia* sp., with *Halophila* spp. having the lowest biomass. *Ruppia* sp. provided the greatest biomass in the

Peel Inlet and was mainly located in the eastern and southern regions, with dense concentrations around Stony Point, Ward Point and Robert Bay. *Zostera* spp. biomass was greatest in the Harvey Estuary and was only marginally lower for the Peel Inlet. The majority of *Zostera* spp. biomass was located just north of Mealup point in the Harvey Estuary. The area covered by *Halophila* spp. was much more extensive than the other two species of seagrass, even though the volume of biomass was significantly lower. The majority of *Halophila* spp. biomass was located in the central basin, eastern and south western regions in the Peel Inlet and at a site near Point Mortiff in the north west of Harvey Estuary (Pedretti *et al.* 2011).

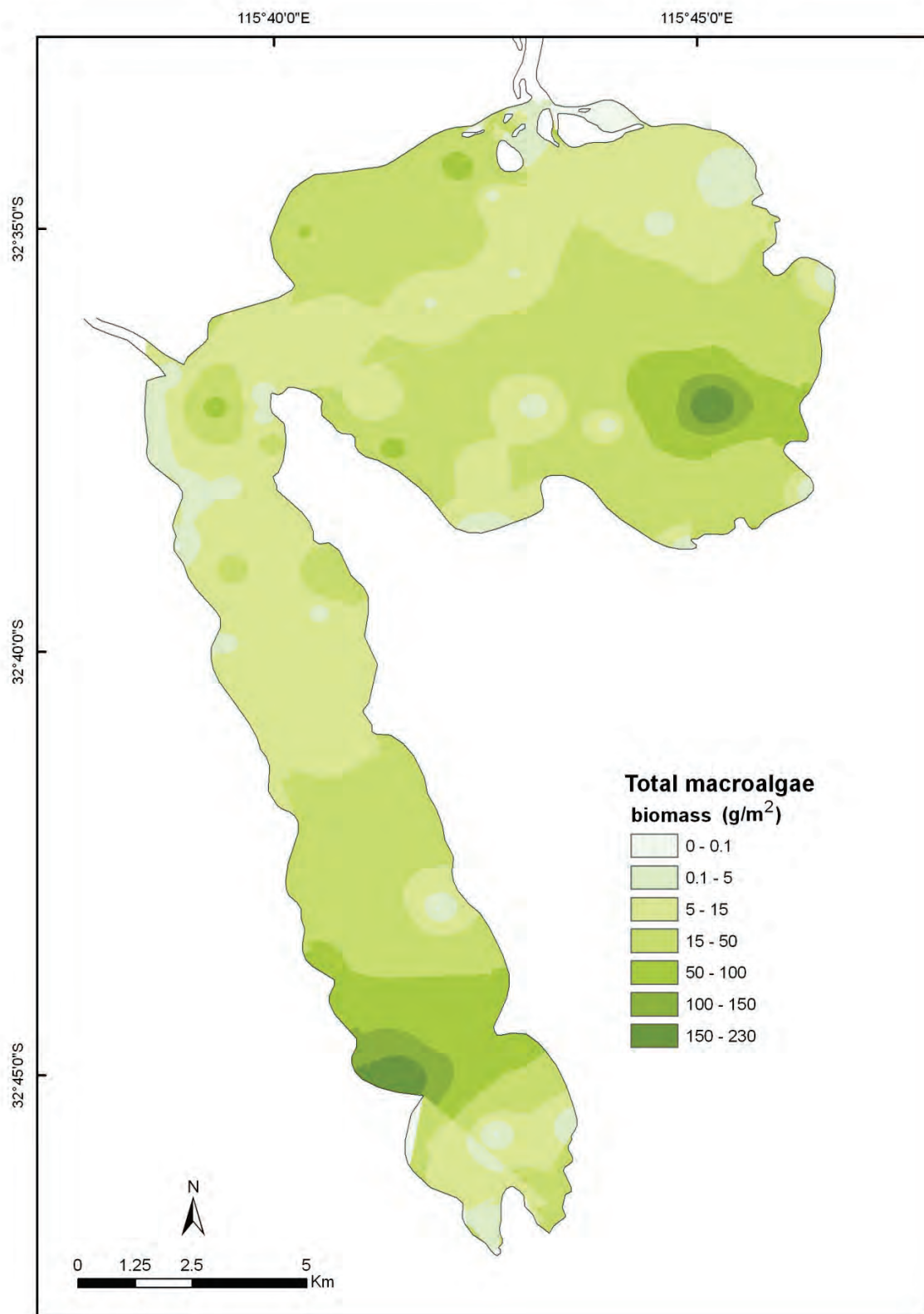


Figure 9.2. Mean distribution of total macroalgae biomass for November/December 2009 in the PHE (Source: Pedretti *et al.* 2011).

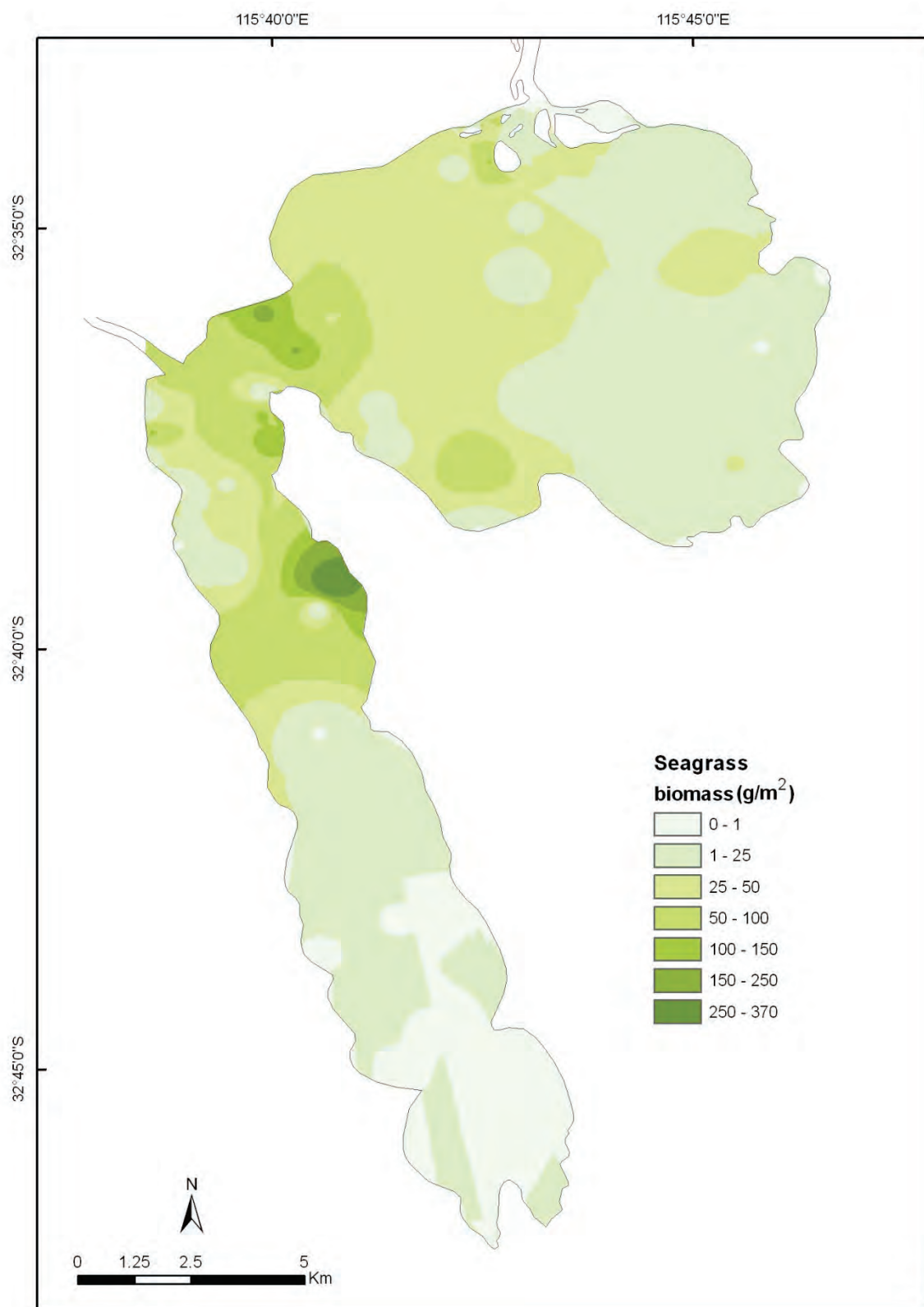


Figure 9.3. Mean distribution of seagrass biomass for November/December 2009 in the PHE (Source: Pedretti *et al.* 2011).

Valesini *et al.* (2009) identified and mapped the nearshore benthic habitats of the PHE as part of a wider-ranging project which extended through a variety of south-western Australian estuaries. The classification of habitat types in the estuary was based on a variety of enduring and biologically-relevant environmental characteristics. These characteristics were measured at 102 locations throughout the estuary basins and lower riverine reaches, and the data set was analysed using multivariate statistical methods. The analysis produced an unsupervised classification of the sites, placing each into one of 17 groups, within which no significant differences could be detected. These groups are subsequently referred to as habitat types. The sites were then identified on a map of the estuary and identified with their habitat type (Figure 9.4). The environmental characteristics of the habitats were examined in the context of the map and interpreted into meaningful habitat descriptions. At the highest level of dissimilarity, riverine habitats were identified, followed by the habitats in the narrow entrance channel. The remaining groups described basin habitats and within the basins, habitats were discriminated by substrate type, percentage cover of submerged vegetation and exposure to wave energy. Detailed descriptions of each of the habitat types and their relative similarities are contained in Valesini *et al.* (2009).

Valesini *et al.* (2009) also sampled fish, hyperbenthic invertebrate fauna and non-enduring environmental variables (salinity, dissolved oxygen etc.) at a selection of the most common habitat types. These non-enduring data sets were then used for two purposes; firstly to characterise the fauna that inhabits each of those habitats, and secondly to evaluate the biological validity of the environmentally defined habitat types. A total of 71 fish species were collected from throughout the Peel-Harvey system, with the greatest diversity being in the channel habitats, and the lowest diversity at the extreme southern reaches of the Harvey estuary. Fish assemblages were significantly different among the habitats examined, and these differences were observable despite significant seasonal variations.

A further development of this habitat classification framework was a predictive element, whereby a site not included in the original classification could be assigned to a habitat type through measuring only its environmental characteristics. The statistical link between the habitat type and its characteristic faunas could then give a prediction of which species were likely to use that site (Valesini *et al.* 2009).

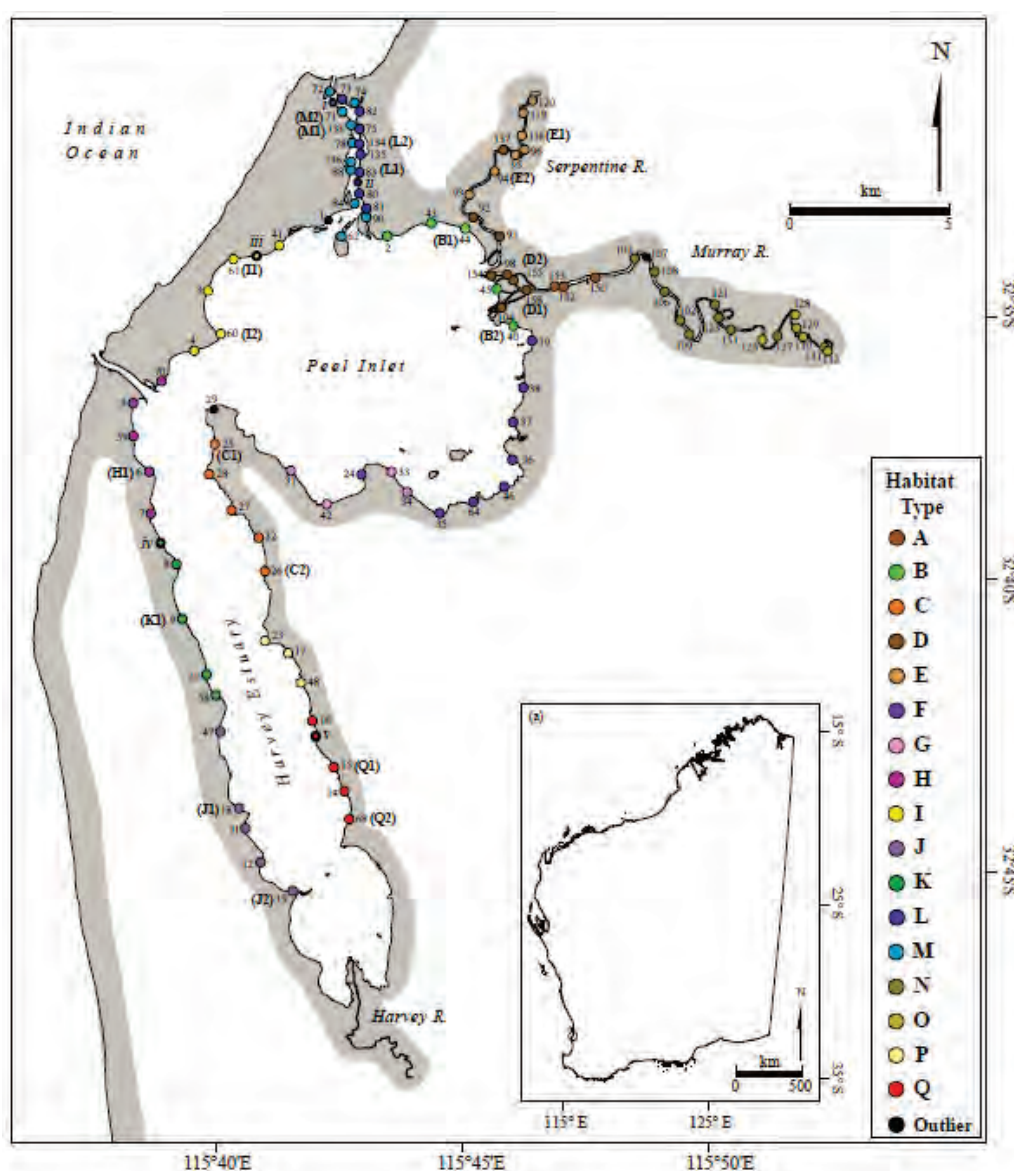


Figure 9.4. Map of the PHE (Source: Valesini *et al.* 2009) showing the location of the nearshore study sites and the habitat type to which each site was assigned, and sites at which fauna and water quality measurements were collected (bold text in brackets).

9.5.1 Commercial Net Fishery

The commercial fishing that occurs in the PHE is considered to be highly unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm due to the limited effort that occurs within the fishery, the relatively low-impact nature of the methods used and the naturally-dynamic nature of the sand/mud bottom habitats where fishing occurs.

Gill and haul nets are used over predominantly mud and sand bottoms throughout the estuary to target specific groups of finfish. These areas are naturally-dynamic habitats as a result of environmental influences, and the fishing operations are considered unlikely to have any significant negative impacts on these habitats within the estuary (Smith *et al.* 2014).

9.5.1.1 Risk Assessment Outcomes

9.5.1.1.1 Seagrass Habitat

2015 SICA Risk Rating: Low

2015 CSA Risk Rating: Medium

The commercial gill and haul netting activities of the WCEMF Area 2 were considered to be a medium-low risk to the benthic seagrass habitats of the PHE.

The haul nets used are lightly weighted along the bottom of the net, with floats along the top of net to minimise bottom contact. Gill nets are generally set in deeper, channel-type areas of the estuary, where there is greater fish movement. The impact from the gear is limited due to the limited number of licences in the fishery, boat length restrictions and variable number of fishing days undertaken by individual fishers throughout the year (average of 117 haul netting and 83 gill netting days per year).

Fishing activities are distributed throughout the estuary, with no known areas of detectable localised disturbance from fishing activities.

9.5.2 Commercial Trap Fishery

Commercial crab traps are mainly set around the western and central regions of the Peel Inlet and Harvey Estuary. There is some seasonal focus of fishing activities, particularly around the Dawesville Channel during winter months (see sample trap line locations in Section 3.1.3.2).

Traps may affect the substrate or organisms that settle upon or are pulled across the substrate during retrieval. Habitat damage by traps depends on the size, weight and trap material, as well as hauling depth and speed, ocean conditions, the number of traps set and the substrate. Based on the nature of the habitat within the PHE, which is mainly a mixed mosaic of sand, algae and seagrass, the size (bottom area of 7850 cm² per trap) and number of traps used (420 total in the fishery) and the limited distribution of effort in the deeper parts of the estuary, the commercial blue swimmer crab trap fishery is considered to be a low risk to the seagrass/algae habitats of the PHE. The overall 'footprint' of the fishery is ~ 33 km², which covers ~ 25 % of the total PHE waters. Sand and associated biota do not get caught in the traps or brought to the surface, and the mesh used is sufficiently large enough to allow for the escape of any sand-dwelling macrobenthos that might be captured. Seagrass is occasionally brought to the surface with the trap, however, the infrequent nature of this occurrence and the small amount of seagrass removed is considered to result in minimal habitat damage (Johnston *et al.* 2014b).

9.5.2.1 Risk Assessment Outcomes

9.5.2.1.1 Seagrass Habitats

2015 SICA Risk Rating: Low

2015 CSA Risk Rating: Low

The commercial crab trapping activities of the WCEMF Area 2 were considered to be a low risk to the benthic seagrass habitats of the PHE.

Seagrass and macroalgae are distributed throughout the estuary, with seasonal changes in biomass due to the ephemeral nature of the estuary. The locations of trapping activities in the estuary are generally known from on-board commercial monitoring undertaken by the Department each year.

Commercial blue swimmer crab trapping are distributed throughout the deeper-water areas of the estuary, and on average, each commercial fisher sets commercial crab traps for 167 days each year, although individual fisher's activities are highly variable. Commercial traps are light, with a wire rim and mesh frame, and are not weighted. The traps are unlikely to be dragged across the bottom during retrieval, due to the shallow nature of the estuary (max. depth 2.5 m).

9.5.3 Recreational Drop Net Fishery

Anecdotal information from Departmental compliance staff have indicated that while fishing occurs throughout the estuary, there are 'hotspots' of activity. For scoop netters, these hotspots generally occur around access points, while drop nets are used throughout the estuary to varying degrees (Figure 9.5).

The recreational drop net fishing that occurs in the PHE is considered to be highly unlikely to reduce habitat structure and function to a point where there would be serious or irreversible harm due to the relatively low-impact nature of the method used and the naturally-dynamic nature of the sand / mud bottom habitats where fishing occurs.

Drop nets are very similar to the crab traps used by the commercial blue swimmer crab sector and result in limited habitat disturbance. The main impact from drop netting activities is due to a very small amount of dragging of the drop nets on the seafloor during retrieval. However, given the shallow depth in which the nets are set, very little dragging is likely to occur. Sand and associated biota does not get caught in the drop nets and are not brought to the surface. Additionally, the mesh used is generally sufficiently large enough to allow for the escape of any sand-dwelling macrobenthos that might be captured (Johnston *et al.* 2014b).

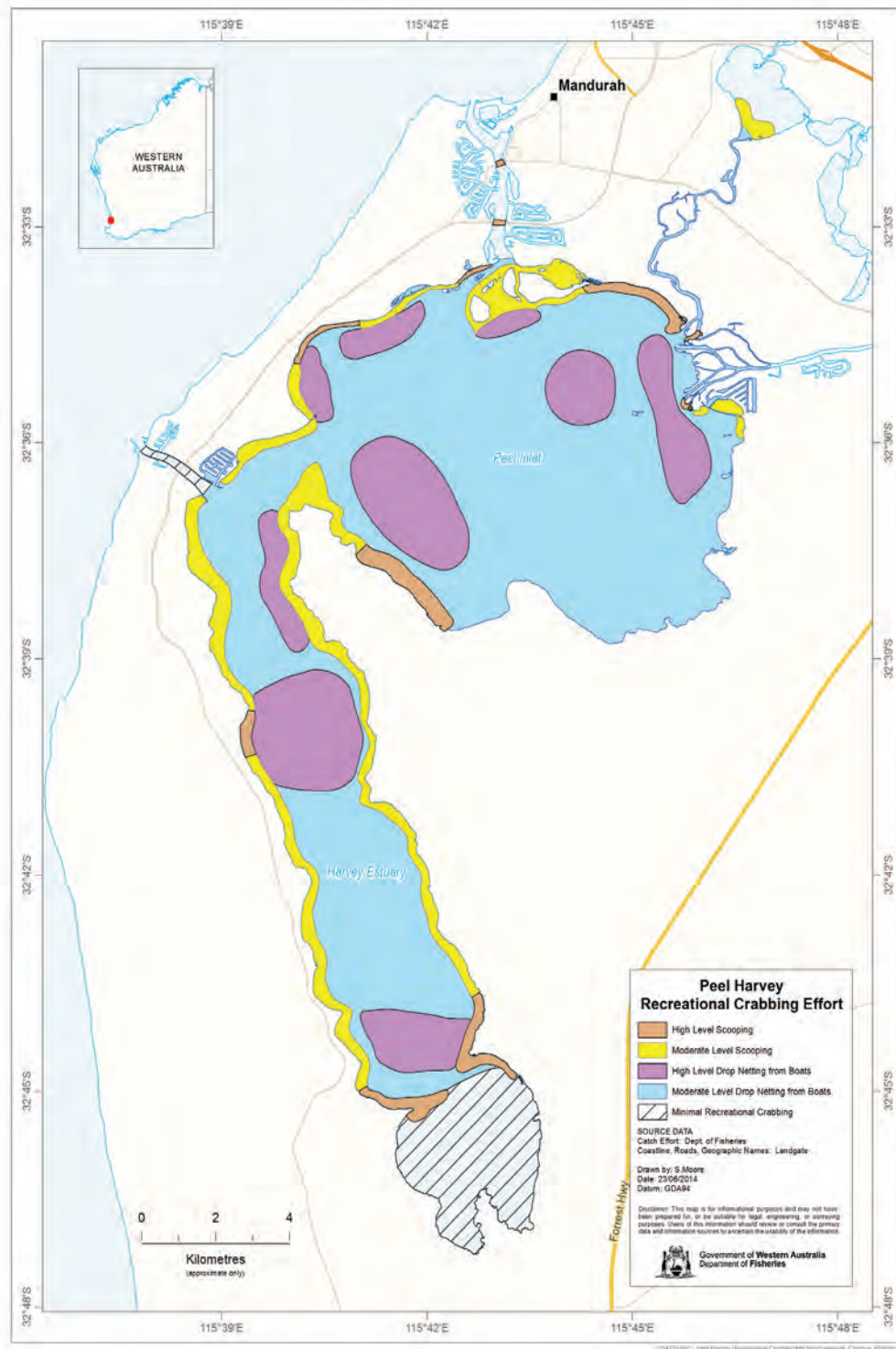


Figure 9.5. Recreational blue swimmer crab fishing ‘hotspots’ in the PHE based on anecdotal information provided by compliance staff in 2014.

9.5.3.1 Risk Assessment Outcomes

9.5.3.1.1 Seagrass Habitats

2015 SICA Risk Rating: Low

2015 CSA Risk Rating: Low

The recreational drop netting activities in the PHE were considered to be a low risk to benthic seagrass and macroalgae habitats.

Seagrass and macroalgae habitats are distributed throughout the estuary, with seasonal changes in biomass due to the ephemeral nature of the estuary. Recreational blue swimmer crab drop nets are primarily set from boats in the deeper water areas of the estuary. Due to the movement of blue swimmer crabs outside the estuary, fishing effort in the recreational fishery is highly seasonal and primarily occurs over the summer/autumn months (November through May).

Recreational drop nets are light, with a wire rim and mesh frame, and are not weighted. Additionally, the nets are unlikely to be dragged across the bottom during retrieval, due to the shallow nature of the estuary. Fishing activities are distributed throughout the estuary, with no known areas of detectable localised disturbance from drop netting activities.

9.5.4 Recreational Scoop Net Fishery

Scoop nets may occasionally come into contact with the estuary floor, as fishers target the crabs while they are swimming or moving along the bottom; however, this interaction is highly unlikely to result in serious habitat damage due to the naturally-dynamic nature of the estuary. Instead, the primary habitat impacts from recreational fishers relate to the movement of fishers along the shoreline and shallow areas of the estuary. Approximately 42 % of the estuary is less than 0.8 m deep and is considered to be available to wading scoop-netters. However, this entire area is not exploited due to limited access points (e.g. roads, parking areas) around the estuary.

9.5.4.1 Risk Assessment Outcomes

9.5.4.1.1 Seagrass Habitats

2015 SICA Risk Rating: Low

2015 CSA Risk Rating: Low

The recreational scoop netting activities in the PHE were considered to be a low risk to benthic seagrass and macroalgae habitats.

Seagrass and macroalgae occur throughout the PHE, with seasonal changes in biomass due to the ephemeral nature of the estuary. Blue swimmer crab recreational scoop nets are primarily used in the shallow, inter-and subtidal shore areas of the estuary. Due to the limited access points available, certain areas of the estuary are more-frequently utilised by fishers using scoop nets, and these areas may experience seasonal localised impacts, primarily over the

summer months when recreational fishing activity is highest. However, any impacts are likely to recover prior to the beginning of the next season.

In addition, the majority of the estuary is not accessed by fishers at such a high intensity and there are significant areas which are not visited by recreational fishers, providing areas of refuge from scoop netting activities.

9.6 Ecosystem

Information on the PHE ecosystem is available from extensive research conducted as part of the monitoring program set up after the opening of the Dawesville Channel (e.g. Hale & Butcher 2007). The PHE supports high levels of primary productivity, with extensive stands of macroalgae and seagrasses, and significant amounts of phytoplankton, which in turn support significant invertebrate populations (Hale & Butcher 2007). Over 50 fish species have also been recorded in the PHE (see Hale & Butcher [2007] for species list). Several marine species were found to spend considerable time in the PHE, which has been attributed to the unusual conditions in the estuary where tidal influence is reduced, the geomorphology of the two basins and the high salinities (Loneragan *et al.* 1986; Potter & Hyndes 1999; Young & Potter 2003). A simplified food web of the PHE has been provided by Hodgkin *et al.* (1981), which is useful for understanding the trophic relationships within the system (Figure 9.6; Hale & Butcher 2007).

The interactions related to nutrient inflows into the PHE are illustrated in Figure 9.7. The current conditions within the estuary result in dilution of nutrients in much of the water column due to the tidal flushing through the Dawesville Channel. However, with high loads of nutrients still entering from the catchment and potentially from waterside urban development, there are localised areas affected by eutrophication, predominantly adjacent to the river inflows. In these areas, and the lower reaches of the rivers, algal blooms are common, in response to high concentrations of nutrients (Hale & Butcher 2007).

The high biomass of phytoplankton results in large loads of organic matter to the sediments, and the decomposition processes lead to de-oxygenation of bottom waters. This has two flow-on effects: the first is a direct effect on fish and other obligate aquatic fauna, which cannot tolerate the anoxic conditions, resulting in fish kills that have been reported in the lower river reaches (Water and Rivers Commission 2004); the second effect is that of the anoxic conditions on the nutrient stores in the sediment. The low dissolved oxygen concentrations disrupts the de-nitrification cycle, which results in the release of ammonium into the water column and affects phosphorus adsorption to sediment particles, resulting in the release of phosphate into the water. These inorganic nutrients are then available for uptake by plants, including phytoplankton and a cycle of eutrophication is set in motion (Hale & Butcher 2007; Figure 9.7).

In 2009, the PHCC commissioned the Centre for Fish and Fisheries Research at Murdoch University to develop a science strategy for the PHE to underpin the ongoing management programs undertaken at the PHCC, state government agencies and local communities. The project developed a science pathway in order to allow for further development and extension

of ecosystem health indices and quantitative / qualitative ecosystem models for the estuary to provide reliable decision-support tools required for management.

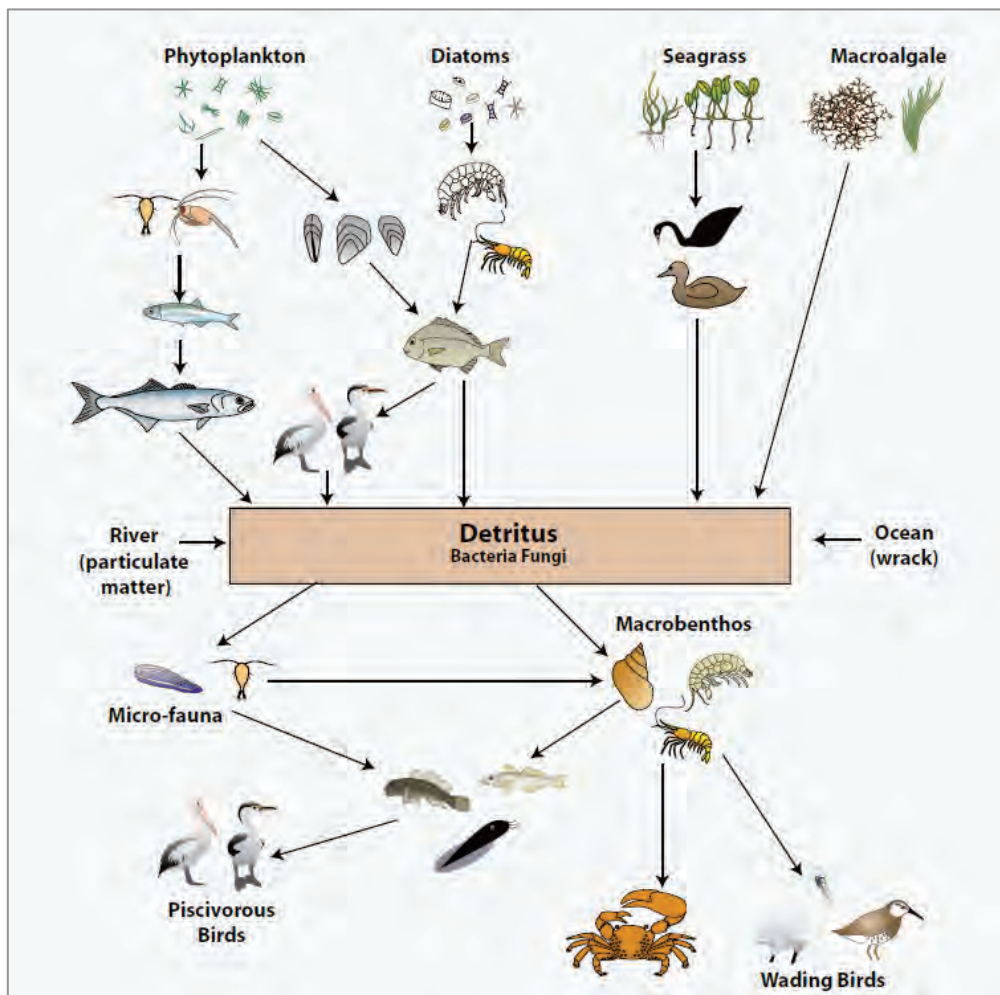


Figure 9.6. Simplified food web of the PHE (Adapted from Hodgkin *et al.* 1981 by Hale & Butcher 2007).

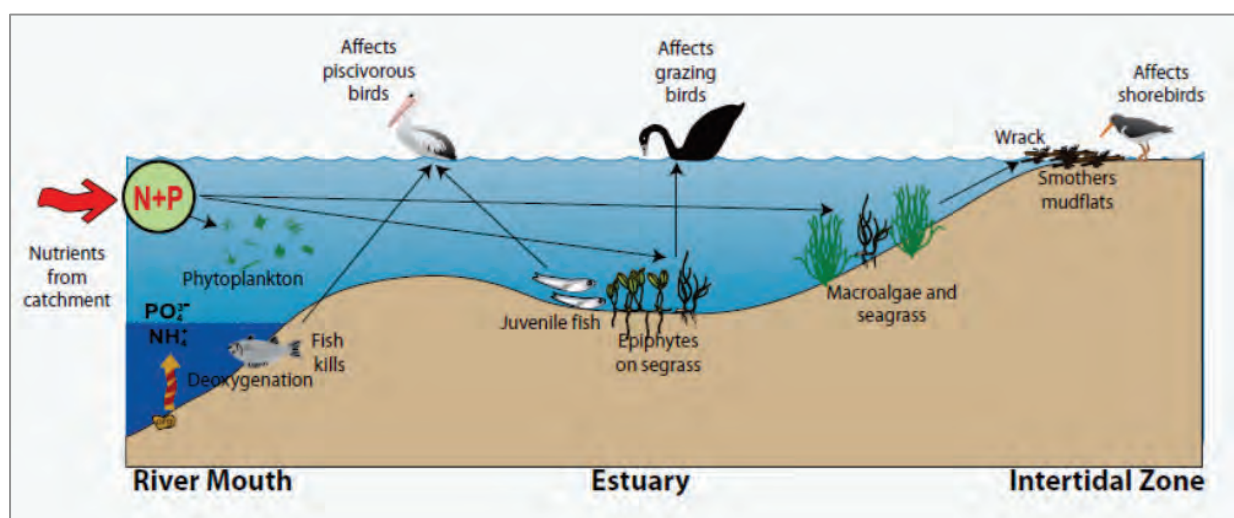


Figure 9.7. Conceptual model of the effects of nutrient inflows on the PHE (Source: Hale & Butcher 2007).

9.6.1 Commercial and Recreational Fisheries

The main ecosystem impacts from commercial and recreational fishing activities in the PHE would be due to the removal of the target species, sea mullet and blue swimmer crabs, as these species make up the majority of the catch.

The fishing mortality of blue swimmer crabs is reasonably low compared to the high levels of natural variation in abundance as a consequence of environmental conditions. The low biomass of crabs retained each year represents a relatively small portion of the total biomass within the south-west region and is effectively renewed annually. Thus, it is not likely that the commercial take of these species will significantly impact the trophic system within the PHE. Similarly, sea mullet occurs in coastal waters in all WA bioregions, with high connectivity due to adult migration and larval dispersal, and the commercial take of sea mullet in the PHE is considered to be a small component of the overall WCB stock.

Other retained species catch in these fisheries are mainly comprised of various finfish species, although a small amount of octopus is also captured in crab traps. These species generally have large distribution ranges and are not known to have any obligate predators that would be impacted by their removal at current levels. Both the commercial (net and trap) and recreational (drop and scoop net) fishing sectors use targeted fishing methods and activities, which minimise the capture of non-target species. The small amount of discards are unlikely to result in any significant trophic impacts.

10. Managing Ecological Impacts

10.1 Commercial Net and Trap Fisheries

There are a number of measures and strategies in place to manage the impact of the commercial net and trap fisheries on byproduct, bycatch and ETP species, habitats and the broader ecosystem. These include measures legislated under the *West Coast Estuarine Managed Fishery Management Plan 2014* and other operational activities, such as the inclusion of voluntary escape gaps in crab traps, including:

- Gear restrictions;
- Effort controls;
- Species restrictions;
- Size and condition restrictions;
- Spatial closures;
- Temporal and Seasonal closures; and
- Reporting.

The measures in place focus on minimising impacts on the ecosystem through maintaining significant biomass levels of the target species, sea mullet and blue swimmer crabs, along with other retained species to minimise the potential for trophic perturbations.

There is an objective basis for confidence that these measures will work. Effort in the fishery is very low (11 licence holders in the net fishery and 10 in the trap fishery), and fishers must abide by strict controls on the gear used. The nets used in the finfish fishery are deployed in a targeted manner to capture schools of finfish, and mesh size restrictions ensure that the species caught are within the appropriate size ranges. The traps used in the crab fishery have been purpose-designed for the capture of legal-size blue swimmer crabs and are considered to be an inefficient way to capture other species. Spatial and temporal closures throughout the fishery area also provide protection to the flora and fauna of the estuary by providing areas / times of refuge from fishing activities.

The targeted fishing methods are reflected in the very low amount of byproduct and bycatch captured in the fisheries. There have also been a low number of ETP species interactions with migratory sea/shore birds reported historically in the net fishery, although no interactions have been reported since 2007. The majority of fishing activities occur in sand / mud- bottom habitats, which are naturally-dynamic habitats as a result of environmental influences, and the relatively low-level of fishing that occurs in the estuary is unlikely to have any lasting impacts on these habitats. In addition, the continuity of the fishery since the mid-1800s is considered to be evidence that the fishery does not have any significant negative ecosystem impacts.

Research on trap impacts in other fisheries has indicated that traps result in minor habitat impacts, even when used in more sensitive habitats, such as coral and rocky reef areas. Eno *et*

al. (2001) examined the short-term effects of fishing with crustacean pots on benthic species, such as sea pens, sea fans and corals, in Great Britain. Overall, observations of traps being dropped and hauled indicated that they had little or no immediate effect on several species that were previously thought to be sensitive. The main exception was the gorgonian coral *Pentapora foliacea*, of which some individuals were badly smashed by potting (Eno *et al.* 2001). Similarly, the impacts of lobster traps on rocky reef and temperate kelp forest habitat comprised of large gorgonian corals and Southern sea palm kelp (*Eisenia arborea*) in Mexico were examined by Shester and Micheli (2011). Initial trials placing traps on *Eisenia* indicated that this habitat could withstand the force of a dropped trap. Therefore, the impacts of dropping traps on gorgonian corals were examined as the ‘worst case scenario’ effects. Impacts from dragging traps over the seabed were also investigated. Dropping traps onto gorgonian corals appeared to have a minimal impact, while dragging traps on the seafloor caused damage to corals more frequently, though this damage was still minor (< 5 % of the skeleton). Within the kelp forest habitat (comprised of highly flexible biogenic structures), the traps appeared to have negligible effects on benthic invertebrates and algae (Shester and Micheli 2011).

Legislated management arrangements are enforced regularly by departmental Fisheries and Marine Officers (FMOs) in the South Metropolitan Region. Compliance is monitored via both at-sea and on-land inspections, with the majority of checks being carried out on land at the point of landing (see Principle 3 [Section 13.4] for more information on compliance).

The MLFA has also developed a Code of Practice (Appendix F), which is a voluntary agreement between the licensees of the WCEMF (Area 2) to:

- Demonstrate the highest level of stewardship possible;
- At all times act as environmental custodians;
- Ensure the use of fishing practices that are environmentally sustainable;
- Lead the way in community education by providing valuable information through the EMS;
- Aid in present and future research projects; and
- Comply with the Departmental Management Plan at all times whilst ensuring new entrants are practicing sustainable fishing methods within the regulations.

The Code of Practice includes operational guidelines for fishing methodology and vessel operations and voluntary management resolutions for resource sharing between commercial and recreational fishers.

The harvest strategies for the finfish and blue swimmer crab resources of the PHE include both long-term and operational objectives for each ecosystem component (see Principle 3 – Section 13.2). These harvest strategies provide guidance for decision-makers for the management of the specified aquatic resources and provide a basis for informed dialogue on management actions with resource users and other stakeholders. Within the harvest strategies,

the reference levels for each component have been set to differentiate acceptable fishery impacts from unacceptable fishery impacts. A review of management arrangements is triggered if annual evaluation against the operational objectives indicates the potential need for a management response (i.e. when the threshold level is breached). This allows for a precautionary approach to management, with potential issues recognised and addressed in a timely manner prior to the start of the following fishing season.

If future research or monitoring indicates that further management is required, this may be achieved through extending the use of current management tools, such as spatial and temporal closures, targeted fishing strategies to optimise expenditure of effort, or a reduction in overall fishing effort.

10.2 Recreational Drop and Scoop Net Fisheries

There are a number of measures and partial strategies in place to manage the impact of the recreational drop and scoop net fisheries on byproduct, bycatch and ETP species, habitats and the broader ecosystem. These measures are legislated under the FRMA and FRMR (and subsidiary legislation) and include:

- Gear / method restrictions;
- Size and condition restrictions;
- Season closure; and
- Daily bag/boat limits.

All recreational fishers operating from a boat must have a RFBL, while shore-based fishers do not have to hold a licence to catch blue swimmer crabs.

There is some objective basis for confidence that these measures will work, based on information directly about the fishery and species / habitats involved. Effective effort in the fishery is restricted by controls on fishing gear, including drop and scoop net size and capacity controls (fishers can set 10 drop nets per boat, regardless of the number of fishers on board). The intensity of shore-based recreational blue swimmer crab fishing within the estuary is limited due to access constraints. Forty-two per cent of the Estuary is less than 0.8 m deep and is considered to be available to wading scoop netters. However, this entire area is not exploited due to limited access points (e.g. roads, parking areas) around the estuary. Effort in the fishery also changes throughout the year, allowing for seasonal refuge from recreational fishing activities. The majority of recreational blue swimmer crab fishing occurs during the summer months, with very little fishing over the winter months (Malseed & Sumner 2001). There is also a closed season from 1 September to 31 October annually, which includes waters in the entire estuary, the Dawesville Channel and all man-made waterways (DoF 2014a).

There are daily personal and boat bag limits on the number of blue swimmer crabs that each fisher (or boat) can have in their possession (10 and 20 blue swimmer crabs, for personal and boat limits respectively), and similar to the commercial fishing sector, recreational fishers are

not permitted to retain berried or undersize (< 127 mm CW) blue swimmer crabs. There are also daily bag limits in place for a number of finfish species that can be caught by recreational blue swimmer crab fishers in the estuary. Within WA, daily bag limits are set for mixed finfish species based on their aquatic environment (i.e. demersal, pelagic, nearshore / estuarine or freshwater) and for individual species. In addition, boat and possession limits also apply¹⁰. There is a mixed daily bag limit of 30 fish per fisher of combined Australian herring, whiting (excluding King George whiting) and garfish. Tailor have an individual daily bag limit of four, and a total mixed species daily bag limit of 16 (in combination with other nearshore / estuarine finfish) per fisher. Daily bag and boat limits also apply for invertebrates, such as mussels and rock lobster (DoF 2014a). Bag and size limits are used to limit fishing mortality and to allow fish to reach maturity and complete their breeding cycle before being removed from the system.

There are measures in place to minimise mortality of ETP species that are highly likely to achieve national and international requirements. The main control measure is the restriction on the gear that can be used to capture blue swimmer crabs in the estuary. The gear used is highly unlikely to capture a protected species, and the fishing methods used generally require fishers to maintain contact with or in close proximity to their gear.

Impacts on habitat from drop nets are likely to be similar to those from commercial crab traps, and research on trap impacts in other fisheries has indicated that traps result in minor habitat impacts, even when used in more sensitive habitats, such as coral and rocky reef areas (see Section 10.1 above).

Management arrangements are enforced regularly by departmental FMOs using both at-sea and on-land inspections, with the majority of checks being carried out on land at the point of landing (see Principle 3 [Section 13.4] for more information on compliance).

The harvest strategy for the blue swimmer crab resource in the PHE includes both long-term and operational objectives for each ecosystem component (see Principle 3 [Section 13.2]) and includes performance indicators and reference levels for both the commercial and the recreational blue swimmer crab fishing sectors (see Section 10.1 for more information on how the harvest strategy is used).

¹⁰ An explanation of bag and size limits is available at: <http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Recreational-Fishing/Recreational-Fishing-Rules/Pages/Bag-And-Size-Limits-Explained.aspx>

11. Information and Monitoring

11.1 Commercial Net and Trap Fisheries

There a high level of both quantitative and qualitative information available on the impacts of commercial fishing activities within the PHE. This information is considered to be sufficient to estimate and assess outcome status for each ecosystem component and support the management measures in place. Sufficient data continue to be collected to detect any increase in risk for each component and to assess ongoing mortalities of all retained and ETP species. This information is considered to be sufficient to allow the main consequences for the ecosystem from commercial fishing activities to be inferred.

Commercial fishers are required to report all retained species catches (kg), effort and any ETP species interactions in statutory monthly catch and effort (CAES) returns to the Department's research division. In order to improve reporting accuracy, fishers have been provided with a *Protected Marine Species Identification Guide* (National Heritage Trust 2005), which contains a picture and brief description of relevant protected species, specific details to include in interactions reports and current contact details for interaction reports. This information is monitored by DoF and is considered to be sufficient to quantitatively estimate the outcome status of ETP species with a high degree of certainty. All CAES returns are checked by Departmental staff, and any possibly erroneous entries or gaps are verified directly with skippers or the fishing company.

The information provided in CAES returns is confirmed by processor unloads, which are also provided to the Department on a monthly basis. This data is also validated by commercial monitoring information collected by Departmental research staff on-board commercial vessels throughout the fishing season.

Further information is available for the dedicated blue swimmer crab trap fishery from monthly on-board observer monitoring conducted by the Department. The current monitoring program was established in 2007. As part of this program, Departmental research staff board one commercial fishing vessel operating in the Peel Inlet region and one operating in the Harvey Estuary region each month. During these surveys, research staff collect information on the catch, size, sex and condition of blue swimmer crabs caught in crab traps, as well as information on bycatch, fishing effort and location (using GPS).

Since the 1980s, there have been intermittent fishery-independent research surveys of the blue swimmer crab population in the PHE (Potter *et al.* 1983; de Lestang 2002; Johnston *et al.* 2014a). Collectively, the data highlight critical aspects of life-history traits, stock structure and changes in blue swimmer crab population dynamics over time. The sampling conducted since 2007 has also enabled the development of recruitment (sexually-immature males and females) and breeding (sexually-mature females) stock indices for blue swimmer crabs in the estuary.

Some information on bycatch composition in the net fishing sector (haul nets only) is available from a bycatch observer program that took place in March 2015 (see Section 9.3.1). Options for ongoing bycatch monitoring in this fishing sector are currently being explored.

11.2 Recreational Drop and Scoop Net Fisheries

Qualitative and some quantitative information are available on the amount of retained and bycatch species caught in the blue swimmer crab recreational fishery from periodic fishing surveys undertaken by the Department. Some of the surveys have focused solely on the PHE, while others have been designed to provide broader-scale estimates of recreational fishing catch and effort in the whole bioregion or State.

To date, two dedicated recreational fishing surveys have been undertaken in the PHE in 1998/99 and 2007/08. These surveys included recreational boat- and shore-based fishers, with a focus on those fishers targeting blue swimmer crabs. Each survey spanned a 12-month period and was stratified by season, time of day, weekdays or weekends and area (each area was further stratified by ramp). Catch (number of each retained species), bycatch (number of each discarded species) effort, fishing location, and demographic data were collected from fishers. Field staff also measured a random sample of crabs and fish from each fisher during the interview (Malseed & Sumner 2001; Lai *et al.* 2014).

More recently, an integrated system involving several survey methods has been used to survey boat-based recreational fishers in WA (Ryan *et al.* 2013). This system uses three complementary components (off-site phone surveys, on-site boat ramp surveys and a remote camera survey) to collect information on fishing catch, effort, location and other demographic information. Two statewide recreational fishing surveys have been completed to date using this methodology, in 2011/12 (Ryan *et al.* 2013) and 2013/14 (Ryan *et al.* in prep.).

These surveys are restricted to boat-based fishers holding a RFBL and were designed to provide estimates of catch and effort for a number of species throughout the state. As such, they are used to provide an estimate of the boat-based blue swimmer crab catch in the PHE. However, they are not considered to provide reliable estimates of the total recreational blue swimmer crab catch or effort, as shore-based fishers are not included in the sample frame.

These four surveys have provided information on both retained and bycatch species by recreational crab fishers within the PHE, as well as spatial distribution of fishing effort throughout the estuary (1998/99 and 2007/08 surveys only). Ongoing monitoring of the blue swimmer crab recreational fishery in the PHE is conducted as part of the integrated recreational fishing survey system, with boat-based fisher information collected every two years.

Should recreational fishers (or other estuary users) encounter an ETP species within recreational fishing gear, they are asked to contact the DPaW via the Wildcare Helpline¹¹.

¹¹ <http://www.dpaw.wa.gov.au/about-us/contact-us/wildcare-helpline>

The information provided by fishers is considered to be sufficient to estimate and assess outcome status for all components and support the management measures in place. Sufficient data continue to be collected to detect any increase in risk for each component and to assess ongoing mortalities of all retained species. As the primary impact from recreational blue swimmer crab fishing is the removal of blue swimmer crabs from the estuary, this information is considered to be sufficient to allow the main consequences for the ecosystem from recreational blue swimmer crab fishing activities to be inferred.

MSC Principle 3

MSC Principle 3 relates to the effective management of the fishery under assessment. Within this context, the fishery must demonstrate that it meets all local, national and international laws and must have a management system in place to respond to changing circumstances and maintain sustainability (MSC 2013).

12. Governance and Policy

This section captures the broad, high-level context of the fishery management system within which the WCEMF (including Area 2) and the Peel-Harvey Blue Swimmer Crab Recreational Fishery is found. This section therefore includes information on:

- The legal and/or customary framework that overarches the fisheries, comprising relevant international treaties, national environmental legislation, national cooperative arrangements, jurisdictional arrangements between the WA State and Commonwealth Governments and the system of governance in WA, including relevant fisheries legislation;
- Consultation processes and policies, as well as the roles and responsibilities of people and organisations within the overarching fishery management system;
- The long-term fishery management objectives; and
- A description of the incentives in place for sustainable fishing.

12.1 Legal and / or Customary Framework

The management systems for the WCEMF Area 2 and the Peel-Harvey Blue Swimmer Crab Recreational Fishery exist within an appropriate legal framework that ensures that they (1) are capable of delivering sustainable fisheries; (2) observe the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and (3) incorporate an appropriate dispute resolution framework.

12.1.1 Compatibility of Laws or Standards with Effective Management

12.1.1.1 Jurisdictional Arrangements for Managing WA Fisheries

There are three different statutory entities responsible for the control and management of fisheries within Australian waters off the coast of WA (1) the Commonwealth Australian Fisheries Management Authority (AFMA), (2) the WA State Fisheries Joint Authority, and (3) the WA Department of Fisheries (the Department).

The WA Government operates under the Westminster system, with the responsible Minister making executive management decisions. For fisheries in WA, the relevant executive decision-maker is the Minister for Fisheries. The Minister for Fisheries has legislative power to turn knowledge and advice he is provided within into action, while the administration of these management arrangements is the responsibility of the CEO of the Department, and the Department more generally.

The Minister / Department is responsible for the sustainable development and management of the State's aquatic resources, fisheries and aquaculture in accordance with its governing legislation. The Department is governed by the *Public Sector Management Act 1994* and is required to provide an *Annual Report* to Parliament, which includes an overview and profile of the Agency and an assessment of the extent to which the Department has achieved its goal of conserving and sustainably developing the State's aquatic resources and the relationship between the service delivered and the cost of resources used in its delivery.

In accordance with the *Offshore Constitutional Settlement 1995* (OCS), the Department's fisheries management responsibilities extend seaward beyond the three nautical mile limit of the State to the 200 nautical mile limit of the Australian Fishing Zone (AFZ). The OCS also sets out that the State will manage all trawling on the landward side of the 200-metre isobath in the waters adjacent to WA and the Commonwealth will manage all deep-water trawling (seaward of the 200-metre isobath). The OCS also provides for some fisheries in both State waters and the AFZ to be managed either jointly by the Commonwealth and State or solely by the Commonwealth (Brayford & Lyon 1995).

Fisheries undertaken in waters adjacent to WA that are managed by the Commonwealth (AFMA) in accordance with Commonwealth legislation include a number of commercial fisheries (e.g. the Northern Prawn Fishery) and all recreational fishing in the waters of any Commonwealth marine park. Fisheries under joint Commonwealth-State jurisdiction are managed under the WA Fisheries Joint Authority (a body comprising State and Commonwealth ministers) in accordance with State legislation.

Except where specifically noted, fisheries involving the following species are managed by the WA Department of Fisheries in accordance with State law:

- All bony fish and sharks (except to the extent they are managed under a Joint Authority or by the Commonwealth);
- All aquatic invertebrates;
- All marine algae; and
- All seagrasses.

The Department provides management, licensing (where applicable), research and compliance and education services for commercial fisheries, recreational fisheries, customary fishing, pearling and aquaculture in all State waters (including marine parks) and the fish processing and charter boat industries. The Department's operations are guided by a *Strategic Plan 2009 – 2018* (currently in Phase 3 [2013 – 2015]), which sets out explicit long-term objectives in four main areas: sustainability, community outcomes, partnerships and agency management (see Section 12.3).

The fully integrated Department is structured around three key service delivery areas:

- **Aquatic Management:** provides management, policy development, licensing and legislation related to the State's commercial and recreational fisheries, pearling, aquaculture, fish processing, the charter boat industry, customary fishing and protection of aquatic ecosystems;
- **Compliance and Education:** provides state-wide fisheries compliance and community education, in accordance with the provisions of relevant legislation; and
- **Research and Monitoring:** provides timely, quality scientific knowledge and advice to support the conservation and sustainable use of the State's fish resources and aquatic systems.

The Department also provides a marine safety service on behalf of the Department of Transport.

Further information on the Department's structure, management, research, compliance and other activities is available in the *Annual Report*¹² and the annual *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries*¹³.

12.1.1.2 Relevant Legislation

The governance system in place for all WA fisheries is subject to a number of international, national and local (state-level) treaties, policies and pieces of legislation.

Fisheries in Australia are subject to international agreements and conventions to which the Australian government is a signatory, such as:

- The *United National Convention on the Law of the Sea* (UNCLOS);
- The *Convention on Biological Diversity* (CBD);
- The *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES);
- The *FAO Code of Conduct for Responsible Fisheries*;
- The *United Nations Fish Stocks Agreement* for straddling and / or highly-migratory fish stocks; and
- Commitments as a member state of the *International Union for the Conservation of Nature* (IUCN).

The Commonwealth DotE is responsible for acting on international obligations on a national level, by enacting policy and / or legislation to implement strategies to address those obligations. As such, all commercial fisheries in Australia are subject to national environmental legislation under the EPBC Act, which is administered by the DotE. The EPBC Act provides a legal framework for the protection and management of nationally- and

¹² <http://www.fish.wa.gov.au/About-Us/Publications/Pages/Annual-Report.aspx>

¹³ <http://www.fish.wa.gov.au/About-Us/Publications/Pages/State-of-the-Fisheries-report.aspx>

internationally-important flora, fauna, ecological communities and heritage places — defined in the EPBC Act as ‘matters of national environmental significance’.

The Commonwealth DotE, through the Commonwealth Minister, has a legislative responsibility to ensure that:

- All Commonwealth-managed fisheries undergo strategic environmental impact assessment before new management arrangements are brought into effect; and
- All fisheries in Australia from which product is exported undergo assessment to determine the extent to which management arrangements will ensure the fishery is managed in an ecologically sustainable way in the long term (see Section 12.1.1.3.1).

12.1.1.2.1 Western Australian Legislation

Within WA, the Department assists the Minister for Fisheries in the administration of the following State acts and regulations¹⁴:

- FRMA;
- FRMR;
- *Pearling Act 1990*;
- *Pearling (General) Regulations 1991*;
- *Fisheries Adjustment Schemes Act 1987*;
- *Fishing and Related Industries Compensation (Marine Reserves) Act 1997*; and
- *Fishing Industry Promotion Training and Management Levy Act 1994*.

The FRMA is the primary instrument for fisheries management in WA, and it adheres to arrangements established under relevant Australian laws with reference to international agreement, including the use of the precautionary principle. The FRMA provides for the creation of subsidiary legislation, in the form of Regulations (i.e. FRMR), Orders, Management Plans, Ministerial Policy Guidelines and Policy Statements.

The FRMA deals with broad principles and the provision of head powers and high-level overarching matters, while the FRMR and other subsidiary legislation deal with the details needed to put these matters into practice. Parts 5 and 6 of the FRMA set out the general regulation of fisheries through the use of orders and regulations and the specific management of fisheries via the declaration or creation / amendment of fisheries management plans.

Fishery management plans in WA set out the operational rules that control managed commercial fishing activities. Specifically, a fishery’s management plan provides the power (pursuant to section 58 of the FRMA) to issue and restrict the number of authorisations and regulate other conditions and grounds related to fishing. There is also the power to set the capacity of a fishery under a management plan (under section 59).

¹⁴ Up-to-date versions of the legislation governing the Department and the Fisheries acts and regulations can be accessed via the Departmental website: <http://www.fish.wa.gov.au/About-Us/Legislation/Pages/default.aspx>.

Under the FRMA, there is a division of power between the Minister for Fisheries and the statutory office of the Department's CEO. In broad terms, it is the Minister for Fisheries who establishes legal and policy framework for fisheries management (under Parts 5 and 6 of the FRMA) in line with consultation processes, while the Department's CEO (and staff) carries out the day-to-day administration of these frameworks.

In 2010, the (then) Minister for Fisheries directed the Department to investigate and scope the requirements for a new WA Act of Parliament to ensure the sustainable development and conservation of the state's aquatic resources into the future. This review recognised the need for the establishment of a clear statutory basis for commercial and recreational fishing access rights as a component in improving the overall robustness of sustainable fisheries management and improving security of resource access for all fisheries sectors. A proposed *Aquatic Resources Management Bill*¹⁵ (ARMA) to replace the FRMA has been introduced to Parliament and expected to be enacted during 2015. Importantly, the ARMA's framework includes a primary emphasis on biological sustainability; clear and transparent guidelines for decision-making; and provisions for a rights-based management approach for all fishing sectors.

An overview of the new ARMA and the objectives of sustainable fisheries and aquatic management policy and how they relate to national and international fisheries law and policy are provided in Department of Fisheries (2010). The guiding principles for the proposed ARMA are that it:

- Provides an integrated aquatic resource management framework which incorporates ESD and biodiversity conservation goals;
- Incorporates the precautionary principle more explicitly;
- Broadens the base of the Act to include aquatic ecosystem issues in the management prescriptions;
- Provides a basis for simplifying subsidiary legislation where possible;
- Provides for greater devolution of decision making and delegation where suitable;
- Provides flexibility for more cost-effective management based on more explicit risk assessment;
- Provides explicit head powers to achieve biological and allocation outcomes across all harvest sectors as required; and
- Provides improved security of access for all resource users.

In addition to the legislative framework, the Department has set out its fisheries and aquatic resource objectives in the WA Government's *Fisheries Policy Statement* (DoF 2012a). This document provides high-level guidance on the Government's preferred approaches to key resource management challenges, including resource management, resource access and

¹⁵ Will become the *Aquatic Resources Management Act* (ARMA) once enacted.

allocation, marine planning and governance and consultative structures. The Government has also recognised that more-detailed policies are needed for a number of other key areas:

- *Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia* (DoF 2015c) — this policy sets out the main requirements of an effective harvest strategy in WA, i.e. operational objectives, performance indicators, reference levels and harvest control rules. This policy is consistent with the *National Harvest Strategy Guidelines* (Sloan *et al.* 2014). However, in addition to the management of target species stocks, it includes unacceptable risks to other ecological resources and sectoral allocation.
- *Aquatic Biodiversity Policy* — The Department is currently drafting an overarching policy that describes the Department's role, responsibilities and jurisdiction in the management of the State's aquatic biodiversity. The policy focuses on five key asset areas (retained fish species; non-retained fish species; endangered, threatened and protected species; fish habitats and ecosystem processes) and seven key threats imposed upon these asset areas (habitat loss, invasive pests, unsustainable harvest, external drivers, lack of information, governance and cumulative impacts).

12.1.1.2.2 Fisheries Adjustment Schemes

The Minister for Fisheries and the Department use the following mechanisms to provide financial relief to commercial fishermen (on a fishery-by-fishery basis) that may be caused by a loss of access or low catches (e.g. caused by market or environmental factors):

- A reduction or deferral of annual access fees under regulation 181 of the FRMR;
- Government funded voluntary 'buy out' of a fishing licence and/or permanent removal of effort under the *Fisheries Adjustment Schemes Act 1987* (FAS Act);
- 'Ex gratia' (Act of Grace) payments to compensate for permanent closures within the waters of a fishery; and
- Compensation awarded under the *Fishing and Related Industries Compensation (Marine Reserves) Act 1997* for loss of access (and commensurate loss of entitlement) to marine parks.

The FAS Act provides the mechanism for structural adjustment through the payment of compensation for the surrender of commercial fishing authorisations. There is also a mechanism under the FAS Act to facilitate industry-funded buy outs, which are generally used to rationalise entitlement and fishing fleets with the aim of optimising economic returns to the remaining licence holders.

It is important to note that in such cases where compensation has been paid, the corresponding commercial fishing effort is permanently removed to guard against changes in behaviour that may result in unsustainable shifts in fishing effort. The mechanisms described above are generally applied in cases where there is a loss of access that would likely result in a financial impact on commercial fishers due to competing priorities or conflicts between resource users (commercial, recreational, conservation or customary). They are not used to address sustainability concerns, which are dealt with via powers under the FRMA.

Nevertheless, the permanent removal of fishing effort following a compensation mechanism often results in a positive sustainability outcome.

For example, over the period 1986 to mid-1996, the Fisheries Adjustment General Scheme (established under the FAS Act) withdrew a total of 187 inshore fishing authorisations, resulting in an overall reduction of about 10 % of the commercial fishing fleet. It succeeded in removing substantial latent effort in the inshore and estuarine sector. Given the age structure of the fishers, coupled with the restricted nature of transferability, it also provided a social ‘safety net’ or exit package for those wishing to cease fishing at relatively modest cost to the taxpayer and industry. A Voluntary FAS (VFAS) was established in 1996 to slowly reduce the number of commercial fishing units in the PHE.

12.1.1.3 Management Framework

12.1.1.3.1 Ecologically Sustainable Development (ESD)

In accordance with international treaties and initiatives, the Australian Government is committed to implementing the principles of ESD. ESD is a dynamic concept that seeks to integrate short- and long-term economic, social and environmental effects into the decision-making processes of government and industry. As per the *National Strategy for Ecologically Sustainable Development* (CoA 1992), ESD is defined as “*using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased*”. ESD is accepted as the foundation for natural resource management in Australia and is a major component of all fisheries legislation, at both Commonwealth and State levels.

The EPBC Act requires the Australian Government to assess the environmental performance of fisheries and promote ecologically-sustainable fisheries management (in line with the principles of ESD). For State-managed fisheries, an independent assessment¹⁶ of a fishery in accordance with the EPBC Act is required for export approval (this is undertaken by the DotE through the Commonwealth Minister for the Environment). In order to meet these requirements, a comprehensive ESD reporting system has been developed for all Australian fisheries (Fletcher *et al.* 2002).

In any assessment using an ESD framework (e.g. export approval), all relevant environmental issues, social and economic outcomes and governance issues are addressed. In WA, these assessments are completed using a risk-based framework to examine the impacts of an individual fishery on retained species, bycatch (including protected species) and habitats, as well as any potential indirect impacts on the broader ecosystem. These assessments are independently-reviewed by the federal environmental agency against the *Guidelines for the Sustainable Management of Fisheries – V2* (CoA 2007), with their ongoing performance reported annually in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries*.

¹⁶ Further information on fishery assessments against the EPBC Act is provided on the DotE website at: <http://www.environment.gov.au/marine/fisheries>

Although WCEMF product is not exported and the fishery has not been assessed under the Commonwealth sustainable fisheries legislation, its management arrangements are in line with the EPBC Act and ESD principles.

12.1.1.3.2 Ecosystem Based Fisheries Management (EBFM)

The Department has implemented Ecosystem Based Fisheries Management (EBFM) as the primary strategy to achieve the goal of ESD for fisheries in WA. EBFM deals with the aggregate management of all fisheries-related activities within an ecosystem or bioregion and takes into account the impacts of fishing on retained species, discarded species, protected species, habitats and the broader ecosystem — regarded as ‘ecological assets’ — and the social and economic impacts of aquatic resource use.

The EBFM framework used in WA was developed in 2010 in partnership with the Western Australian Marine Science Institution (WAMSI) and the FRDC. The framework provides the operating policy / basis for implementing sustainable fisheries and ecosystem management in WA and is based on the global standard for risk assessment and risk management (AS/NZS ISO 31000). The framework provides a step-by-step process (see Fletcher *et al.* 2010) to establish priorities, allowing the Department to focus on managing resources most at risk and of the most value to the community. It also complements IFM, which allocates a percentage of the catch to each fishing sector, helping to ensure fair access and minimise conflicts.

Within the EBFM framework, WA has been divided into six aquatic bioregions with a high-level set of ecological resources / assets that are to be managed under the FRMA identified for each bioregion¹⁷. The risks associated with each individual ecological asset are examined separately using formal qualitative risk assessment (consequence × likelihood) or more-simple problem assessment processes (as detailed in Fletcher 2005; Fletcher *et al.* 2011). All risk scoring considers both the current level of activities and management controls already in place.

The risk levels are used as a key input in the Department’s Risk Register, which combined with the assessment of the economic and social values and risk associated with these assets, is an integral part of the annual planning cycle (Figure 12.1) for assigning Departmental activity priorities (e.g. management, research, compliance, education, etc.).

The Department’s Risk Register feeds into guidance documents for long-term Departmental activities, which are documented in Fish Plan and a five-year research plan (Figure 12.1). Fish Plan is the guiding document to assist the Department in achieving its desired agency-level outcomes, which are measured by the Department’s key performance indicators and published in the Department’s *Annual Report* to Parliament. Fish Plan provides a planned, structured approach to the management of fishery resources, including review of the management arrangements for fish stocks, assessment and monitoring of these stocks and compliance planning. Fish Plan includes two planning schedules; the first describes the key outcomes to be delivered at a resource / fishery level during the next five years (and

¹⁷ More information on the EBFM framework in WA is provided in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher & Santoro 2014).

potentially into the next five-year cycle). Within this schedule, fish resources considered to be at ‘higher’ risk are likely to receive higher priority than those where the risk is lower. The second schedule provides a description of the other key functions undertaken by the Department related to management of fishery resources. Many of these functions have an annual cycle, such as licensee and stakeholder liaison and fee setting; others are addressed on an ‘as needed’ basis, such as marine park planning. More information on the Department’s research plan is provided in Section 13.5.

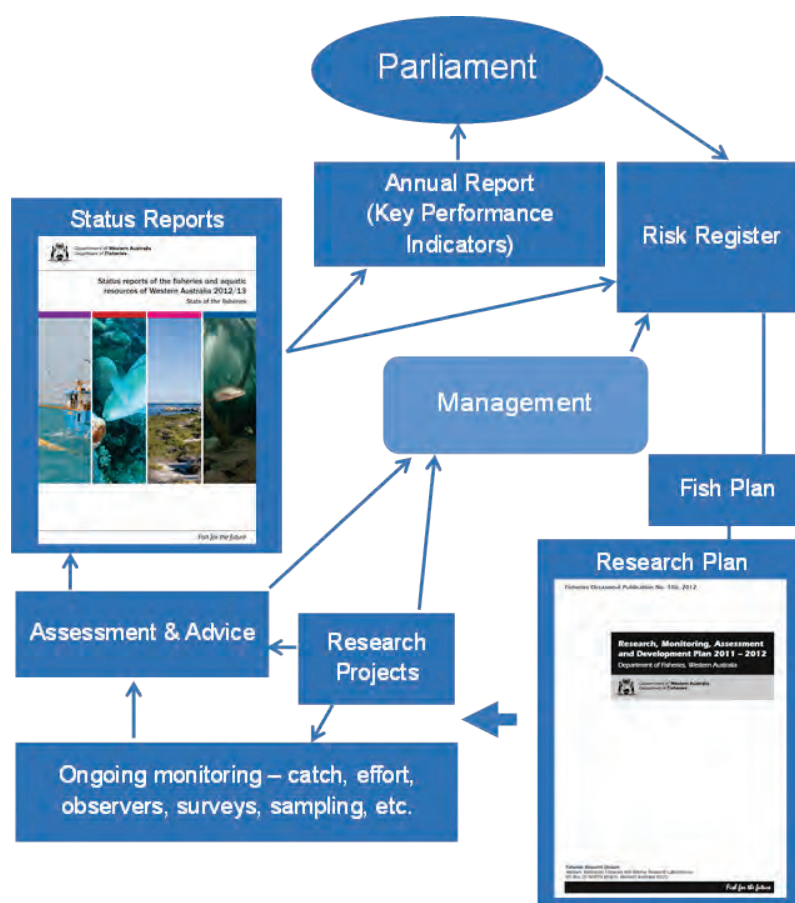


Figure 12.1. Outline of risk-based planning cycle used by the Department to determine annual priorities and activities.

12.1.1.4 Resourcing

The costs of managing the aquatic resources in the PHE, including conducting relevant research and ensuring adequate compliance, are met from a variety of sources. In particular, significant contributions can come from:

- commercial fishing licence fees;
- the Recreational Fishing Account (from recreational fishing licence fees);
- State Government Consolidated Revenue;
- Fisheries Research and Development Corporation (FRDC);
- Western Australian Marine Science Institution (WAMSI);

- Commonwealth Scientific and Industrial Research Organisation (CSIRO);
- Australian Research Council (ARC) linkage grants (with a university partner);
- the National Heritage Trust;
- the Natural Resource Management Rangelands Catchment Coordinating Group; and
- Commonwealth World Heritage Funding.

From July 2010, all managed commercial fisheries were subject to a new funding model that replaced a cost-recovery system. The new funding model aimed at improving flexibility for resourcing priority management needs and providing equity in how much licensees pay in access fees and greater certainty of funding and access rights. This involves all managed commercial fisheries in WA paying an access fee equivalent to 5.75 % of the gross value of production (GVP) of the respective fishery.

12.1.2 Resolution of Legal Disputes

All changes to or new fisheries legislation, including subsidiary legislation, are potentially subject to review through the disallowance process of State Parliament. All subsidiary legislation is also reviewed by the Joint Standing Committee on Delegated Legislation, who may seek further advice on the reasons for the legislation and potentially move to disallow. In this way, there is Parliamentary and public scrutiny of all fisheries legislation.

Disputes in the fishery are informally dealt with through the ongoing processes of communication and consultation between the fishery's management and research staff and industry (see Section 12.2 for more information); however, there are also well-established formal dispute mechanisms for administrative and legal appeals of decisions taken in respect to fisheries (as prescribed in Part 14 of the FRMA).

Most decisions made by the CEO¹⁸ of the Department and disputes regarding the implementation and administration of fisheries legislation can be taken to the Western Australian State Administrative Tribunal (SAT)¹⁹ for review, or to the WA (and Commonwealth) Court System²⁰. The decisions of the SAT and Courts are binding on the Department²¹, and all SAT decisions must be carried out by the Department (under section 29(5) of the *State Administrative Tribunal Act 2004*). These mechanisms have been used and tested across several fisheries (see Section 13.3.6 for examples).

12.1.3 Respect for Rights

12.1.3.1 Native Title Rights

Native title was first recognised by the High Court of Australia in 1992 with the Mabo decision²² that overturned the idea of 'terra nullius', i.e. that the Australian continent did not

¹⁸ When exercising his powers pursuant to the FRMA, the Director General of the Department is referred to as the CEO

¹⁹ <http://www.sat.justice.wa.gov.au>

²⁰ http://www.courts.dotag.wa.gov.au/C/courts_history.aspx

²¹ See <http://decisions.justice.wa.gov.au/SAT/SATdcn.nsf> for details

²² http://www.austlii.edu.au/cgi-bin/sinodisp/au/cases/cth/high_ct/175clr1.html?stem=0&synonyms=0&query=%20mabo%201992

belong to anyone at the time of Europeans' arrival. It recognised for the first time that indigenous Australians may continue to hold native title and to be uniquely connected to the land.

According to the Western Australian Land Approvals and Native Titles Unit²³, native title is a form of land title that recognises the unique ties some Aboriginal groups have to land. Australian law recognises that native title exists where Aboriginal people have maintained a traditional connection to their land and waters, since sovereignty, and where acts of government have not removed it.

Aboriginal and Torres Strait Islander people can apply to the courts to have their native title rights recognised under Australian law. Statutory aboriginal native title rights are managed under the Commonwealth *Native Title Act 1993* (NT Act)²⁴. The National Native Title Tribunal²⁵ facilitates the negotiation of indigenous land use agreements following a claim or determination and is required to keep registers of approved native title determination and native title claims.

The native title of a particular group will depend on the traditional laws and customs of those people. The way native title is recognised and practised may vary from group to group, depending on what is claimed and what is negotiated between all of the people and organisations with an interest in that country. There is currently a native title negotiation underway between the South West Land and Sea Council and the WA Government²⁶.

A 2013 Australian High Court decision related to the application of State fisheries law to native title holders fishing for abalone in their local area in South Australia²⁷. The decision concluded that the State fisheries legislation did not extinguish native title rights to fish and that the defence under section 211 of the NT Act was applicable. It is therefore unlikely that fisheries legislation in WA has the effect of extinguishing native title rights to fish and that the defence provided by section 211 of the NT Act will apply to most cases where the right being exercised is for a traditional, non-commercial purpose and where the person is in fact, an Aboriginal person.

12.1.3.2 Customary Fishing in WA

The WA Government and the Department are committed to working with the customary fishing sector to recognising customary rights. Section 6 of the FRMA acknowledges the rights of Aboriginal persons fishing for a customary fishing purpose —

²³ <http://www.dpc.wa.gov.au/lantu/WhatIsNativeTitle/Pages/FAQs.aspx>, accessed on 3 October 2013 at:

²⁴ <http://www.comlaw.gov.au/Series/C2004A04665>

²⁵ <http://www.nntt.gov.au/Pages/Home-Page.aspx>

²⁶ <http://www.dpc.wa.gov.au/lantu/Claims/Pages/SouthWestSettlement.aspx>

²⁷ <http://www.hcourt.gov.au/assets/publications/judgment-summaries/2013/hca47-2013-11-06.pdf>

“Aboriginal persons, application of Act to

An Aboriginal person is not required to hold a recreational fishing licence to the extent that the person takes fish from any waters in accordance with continuing Aboriginal tradition if the fish are taken for the purposes of the person or his or her family and not for a commercial purpose.”

The FRMA defines customary fishing as *“fishing by an Aboriginal person that —*

(a) is in accordance with the Aboriginal customary law and tradition of the area being fished; and

(b) is for the purpose of satisfying personal, domestic, ceremonial, educational or non-commercial communal needs.”

S258 (1) (ba) of the FRMA provides the power to make regulations to manage customary fishing in WA.

The Department released a *Customary Fishing Policy* position statement in 2009²⁸, which states that *“customary fishing applies, within a sustainable fisheries management framework, to persons:*

- of Aboriginal descent;*
- fishing in accordance with the traditional law or custom of the area being fished; and*
- fishing for the purpose of satisfying personal, domestic, ceremonial, education or non-commercial communal needs.”*

Under the proposed ARMA, a quantity of a specified aquatic resource²⁹ will be reserved for conservation and reproductive purposes, then setting a sustainable allowable harvest level for use by the fishing sectors. The quantity “reserved” also includes an allowance for customary fishing and public benefit purposes such as scientific research. Thus, a specific share does not have to be allocated to the customary sector as part of IFM allocation processes (see Section 4.4). The share is set aside prior to setting an allowable harvest level for a resource and customary fishing can continue in accordance with existing customary fishing arrangements.

To date, the only survey designed to document the Indigenous catch was the National Recreational and Indigenous Fishing Survey carried out in 2000/01 (Henry & Lyle 2003). While this survey did not present data separately for regional WA, what is clear from this report is that the vast majority of the Indigenous catch is from inland and coastal waterways.

²⁸ http://www.fish.wa.gov.au/Documents/customary_fishing/customary_fishing_policy.pdf

²⁹ In this context “aquatic biological resource” may refer to a single species of fish, or a number of species or species groups. The resource may also be defined by area. Several “fisheries” and sectors may operate on a resource.

12.2 Consultation, Roles and Responsibilities

The management system for the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery has effective consultation processes that are open to interested and affected parties. The roles and responsibilities of organisations and individuals who are involved in the management process are clear and understood by all relevant parties.

12.2.1 Roles and Responsibilities

One of the first steps in the consultation process is identifying the key and other interested stakeholders relevant to a fishery. The number and type of stakeholders vary depending on the type of fishery, target species, the area of operation and whether or not the fishery contains a significant recreational or customary fishing component. For the fisheries operating in the PHE, key stakeholders include the Department (and relevant personnel), peak commercial and recreational sector bodies, and other interested parties.

12.2.1.1 Department of Fisheries

The roles and responsibilities of the State of WA in fisheries management is explicitly outlined in the WA Government's *Fisheries Policy Statement* (DoF 2012a) and the OCS arrangements, particularly in relation to the management of fisheries outside the three nautical mile state-waters boundary. Departmental planning and prioritisation is done in conjunction with the CEOs of the peak bodies for the commercial (WAFIC) and recreational (Recfishwest) fishing sectors in WA.

The members of the Department's Corporate Executive and an organisational chart are published in the Department's *Annual Report*. With respect to the PHE, key personnel to whom the responsibility of ensuring management, research and compliance outcomes, including proper prioritization of Departmental funding, include:

- West Coast Bioregion Program Manager (Aquatic Management Division);
- West Coast Bioregion Principal Management Officers (Aquatic Management Division);
- Supervising Scientists – Invertebrates and Finfish (Research Division);
- Senior Scientists – Invertebrates and Finfish (Research Division);
- Metropolitan Region South Compliance Manager (Regional Services); and
- Metropolitan Regional Managers (Aquatic Management Division and Regional Services).

The Minister / Department is responsible for advising licensees, WAFIC and Recfishwest of Ministerial / Departmental decisions which are the subject of a consultation process. Responsibilities of the Department in formal consultation arrangements with WAFIC include that it:

- Provides annual funding to WAFIC equivalent to 0.5 % of WA commercial fishing GVP (based on a three year average), plus a pro-rata amount equivalent to 10 % of

water access fees paid by aquaculture and pearling operators. Payments to WAFIC are made by six monthly instalments each year;

- Works with WAFIC in a manner consistent with WAFIC's role as the peak body representing commercial fishing interests in WA; and
- Engages with WAFIC, sector bodies and commercial fishing interests according to WAFIC Operational Principles (see Table 12.1 below).

The Minister / Department is also responsible for ensuring that the recreational fishing sector, through Recfishwest, is formally consulted on proposed changes to recreational fisheries management and is advised of Ministerial / Departmental decisions which are the subject of a consultation process. The Minister is responsible for providing Recfishwest with a proportion of the income generated from annual recreational fishing licence fees to undertake its role as the peak body representing recreational fishing interests in WA.

The Department or Minister may seek and provide advice directly through peak bodies (WAFIC and Recfishwest) and / or sector associations. For example, WAFIC and Recfishwest, have direct input into the annual planning and priority setting process used to determine management, compliance, research and other priorities.

12.2.1.2 Peak Sector Bodies

The WA Government formally recognises WAFIC and Recfishwest as the key sources of coordinated industry advice for the commercial and recreational sectors, respectively (DoF 2012a).

12.2.1.2.1 WAFIC

WAFIC³⁰ is the peak industry body representing professional fishing, pearling and aquaculture enterprises, as well as processors and exporters in WA. It is an incorporated association that was created by the industry more than 40 years ago to work in partnership with Government to set the directions for the management of commercial fisheries in WA. WAFIC aims to secure a sustainable industry that is confident of:

- Resource sustainability and security of access to a fair share of the resource;
- Cost-effective fisheries management;
- That its business can be operated in a safe, environmentally-responsible and profitable way; and
- That investment in industry research and development is valued and promoted.

WAFIC's responsibilities include coordinating Government funding for industry representation and taking on a leadership role for matters which involve or impact on or across a number of fisheries, or are of an industry-wide or generic nature. WAFIC also represents those commercial fishing sectors that do not have capability of self-representation.

³⁰ <http://www.wafic.org.au/>

WAFIC's responsibilities can be summarised as:

- Providing effective professional representation of commercial fishing interests and the commercial fishing sector to Government, industry, other relevant organisations and the community. This includes engaging, facilitating and consulting, as necessary in order to meet this responsibility. For example, WAFIC representatives attend WCEMF annual management meetings (see Section 12.2.2.2.1) to advocate on behalf of the commercial fishers;
- Providing representation of commercial fishing interests on fisheries management and Ministerial committees, as required;
- Documenting priority issues for commercial fishing interests (by 30 March) each year to the Department;
- Providing feedback to the Department on proposed deliverables and budget priorities for expenditure of the Fisheries Research and Development account;
- Engaging with Recfishwest and other appropriate parties with a view to identifying joint priorities and solutions to issues of shared concern. For example, Recfishwest, WAFIC and the MLFA have jointly supported the application for MSC full assessment for the sea mullet and blue swimmer crab resources of the PHE;
- Engaging in promotion, education and awareness of key sustainability messages consistent with best practice fisheries management and objects of the FRMA; and
- Conducting agreed activities that are consistent with the FRMA as it relates to the provision of assistance to, or promotion of, the fishing industry (i.e. s238(5)(1) of the FRMA).

WAFIC's Operational Principles (Table 12.1) outline consultation responsibilities of the organisation in dealing with policy issues that could affect, as a whole, the commercial fishing, aquaculture, and pearling industries; issues which primarily affect one sector, but could have broader industry implications; and issues that affect only one specific industry group.

Table 12.1. WAFIC's Commercial Fisheries Consultation Operational Principles.

Principle	Responsible Body	Example
On generic policy issues which could affect, as a whole, the commercial fishing, aquaculture, and pearling industries	WAFIC	Bioregional marine planning; safety, education and training; research and development policy and biosecurity
On policy issues which currently primarily affect one sector but which could have implications for the broader industry	WAFIC will nominate the relevant sector body and WAFIC and that body will jointly represent industry	WAFIC would represent industry on marina and port access issues which may primarily initially impact on the fishing industry in regard to certain locations but have precedents for the rest of the industry for other locations; and on animal welfare
On issues which affect only one specific industry group	The relevant sector association (e.g. MLFA) would represent itself but WAFIC would be kept informed and may have a statutory consultation role.	Regulation of gear design or compliance (WAFIC and specific industry associations)

12.2.1.2.2 Recfishwest

Recfishwest³¹ is an incorporated association and receives 15 % of the revenue raised from recreational fishing licence fees to advocate for, and represent, the recreational fishing sector. Key roles undertaken by Recfishwest include undertaking consultation on management reforms, advocating for the sector on issues of significance, education, and overseeing recreational fishing initiatives.

Recfishwest's peak body operations and its representation role includes:

- Effective representation of the Western Australian recreational fishing community;
- Provision of professional advice to Government on issues affecting recreational fishing. For example, Recfishwest representatives will co-ordinate and facilitate the consultation with the recreational sector on the allocation proposals for the PHE blue swimmer crab resource with the IFAAC;
- Coordination of recreational fishing stakeholder views on management proposals;
- Advice on use of the Recreational Fishing Account; and
- Assistance with education of fishers and promotion of responsible fishing. An example of this is recreational fishing clinics held by Recfishwest in Mandurah.

³¹ <http://www.recfishwest.org.au/>

Recfishwest's monthly electronic newsletter reaches over 32 000 recreational fishers, keeping subscribers up to date with recreational fishing initiatives, research results and issues affecting the recreational fishing sector.

12.2.1.3 Other Interested Parties

Other stakeholders interested in the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery include:

- Organisations / institutions undertaking research relevant to PHE (e.g. WAMSI³² and universities);
- State Government agencies (e.g. DPaW³³, Department of Transport³⁴);
- Local Government (e.g. City of Mandurah and Shire of Murray);
- Conservation sector representatives (e.g. the Peel-Harvey Catchment Council and the Conservation Council of WA³⁵);
- Native Title claimant and their representatives (Noongar people, represented by the South West Land and Sea Council³⁶);
- Fish processors and their representatives;
- Retailers and consumers; and
- The wider community.

12.2.2 Consultation Processes

The management system includes consultation processes that regularly seek and accept relevant information, including local knowledge, and the system demonstrates consideration of information and explains how it is used or not used.

The WA Government's commitment to consultation with stakeholders is set out in the WA Government's *Fisheries Policy Statement* (DoF 2012a). In 2009, a review of consultation arrangements between the fishing sector and Government was undertaken with the following objectives:

1. Enhanced efficiency, cost effectiveness and flexibility.
2. Clarification with respect to:
 - a. fishing sector representation;
 - b. expertise-based advice to the Department of Fisheries; and
 - c. Department of Fisheries as the primary source of management advice to the Minister for Fisheries.

³² <http://www.wamsi.org.au/>

³³ <http://www.dpaw.wa.gov.au/>

³⁴ <http://www.transport.wa.gov.au/>

³⁵ <http://ccwa.org.au/>

³⁶ <http://www.noongar.org.au/index.php>

3. Enhancement of the Department's engagement with industry, stakeholders and the public.

The review process resulted in the development of a broad framework (Figure 12.2) for industry consultation in Western Australia, incorporating:

- Recognition of WAFIC as the peak body representing the commercial fishing sector (including pearling and aquaculture), with funding provided by Government to support WAFIC in this role.
- Recognition of Recfishwest as the peak body representing the recreational fishing sector, with funding provided by Government to support Recfishwest in this role.
- Capacity for these peak bodies to perform consultation functions on behalf of the Minister. In this regard, the Department has entered into Service Level Agreements (SLAs) with WAFIC and Recfishwest for the provision of specified consultation services with the commercial and recreational sectors. This is discussed in more detail below.
- The replacement of Management Advisory Committees (MACs) with two key sources of advice: (1) the Department as the key source of Government advice on fisheries management and (2) WAFIC and Recfishwest as the key sources of coordinated industry advice for the commercial and recreational sectors, respectively.
- Establishment of an Aquatic Advisory Committee (AAC) to provide independent advice to the Minister or the Department on high-level strategic matters; and
- The establishment by the Minister (or Department) of tasked working groups to provide advice on specific fisheries or operational matters. Tasked working groups differ to MACs in that they are expertise based and operate on the basis of a written referral on a specific matter. Tasked working groups have been established in the past to provide advice on matters such as water access (lease) fees, strengthening of access rights in the fisheries legislation, development of a Government *Fisheries Policy Statement* (DoF 2012a), and determining catch shares among sectors.

These processes ensure that stakeholders and the community more generally have access to relevant information that shapes advice that is provided to the Minister. Making information available and providing for a discussion and exchange of ideas encourages input from stakeholders and the community in the management process.

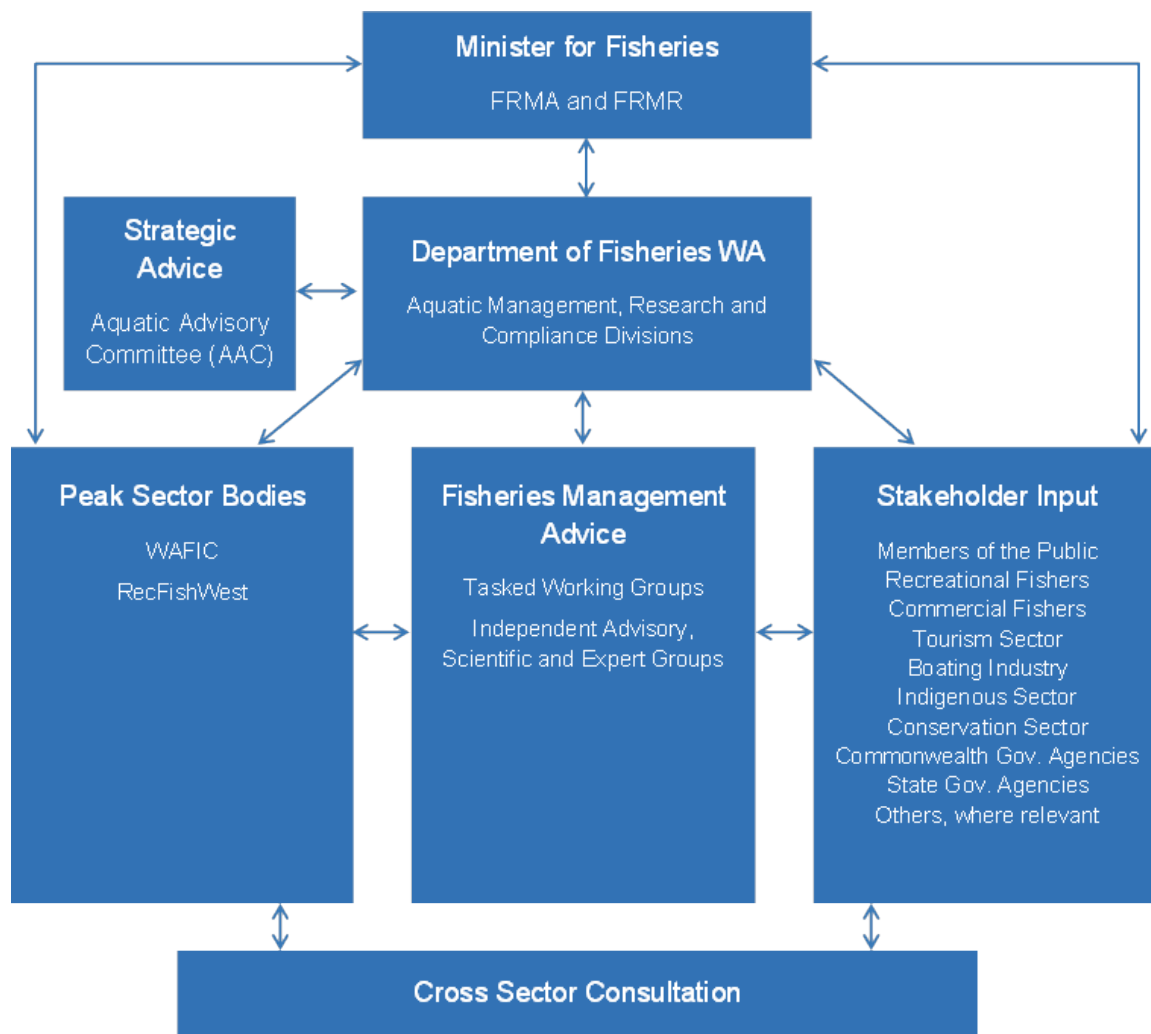


Figure 12.2. Broad fisheries management consultation framework in WA

12.2.2.1 Statutory Consultation

Section 64 and 65 of the FRMA set out the legislative consultation requirements the Minister must adhere to when determining a new management plan or amending an existing management plan. Section 65 has ‘natural justice’ origins, in that a person whose rights may be about to be affected should have an opportunity to be heard before any adverse action/impact is given effect.

Given the commercial aspects of fishing access rights and the potential for amendments to management arrangements to adversely affect these interests, it is fundamental that the interest holders:

- are consulted;
- have the opportunity to respond to any proposed amendments by the Minister/Department; and

- have these responses genuinely considered by the decision-maker prior to the final decision³⁷.

In accordance with these principles, the Minister must consult with all licence holders in the relevant fishery before determining or amending a management plan. The Department generally undertakes consultation work on the Minister's behalf. However, the statutory consultation function is presently conducted by WAFIC on behalf of the Department under the SLA. Management plans for managed fisheries contain provisions that specify the person/s that must be consulted prior to amendments being made to management plans. In the case of the WCEMF, this includes all licence holders of the fishery.

For other fishing "access rights", such as exemptions and regulation licences, statutory provisions are silent as to procedural requirements on amendments to management arrangements. In the absence of any statute specifying consultative procedures, the decision-maker must have regard for common law principles to afford natural justice to these groups of fisheries licence holders.

12.2.2.2 Obtaining Information

The Department / Minister may seek advice from a number of sources, including external expert advice and internal management advice, when considering policy or management changes. Research projects using expert advice on data and other information is often sought and underpins management changes (e.g. Johnston *et al.* 2014a).

The Department / Minister may also seek and provide advice directly through the peak sector bodies (WAFIC and Recfishwest) and / or other sector associations. For example, WAFIC and Recfishwest have direct input into the annual planning and priority-setting process used to determine management, compliance, research and other priorities for the Department.

Under the SLA, the Department / Minister is responsible for advising licensees, WAFIC and Recfishwest of management decisions that are the subject of a consultation process. In carrying out the consultation functions on matters referred to the organisation by the Minister or the Department, WAFIC and Recfishwest must:

- Distribute proposed changes to management arrangements that include the Minister's / Department's reasoning for the proposal(s) and the information on which the proposal(s) is based to all licence holders in the relevant commercial fishery, or to all known appropriate recreational fishing networks;
- Describe the method by which licence holders may provide their views; this may be by way of inviting written responses, or it may involve additional processes, such as the establishment of appropriate forums in which licence holders can discuss and deliberate on the merits of proposed changes prior to putting forward individual views as well as collective views, where appropriate;

³⁷ Section 65(4) of the FRMA provides for the Minister to amend a management plan without consultation if, in the Minister's opinion, the amendment is required urgently or is of a minor nature. This might include the need for amendments for emergency sustainability reasons.

- Ensure that licence holders/interested parties have a reasonable period in which to consider their position and respond; and
- Ensure the decision-maker is fully aware of the views being put forward, in order to ensure the decision maker gives proper and genuine consideration to the views being put forward.

12.2.2.2.1 Annual Management Meetings

The Department has a general practice of holding regular (often annual) management meetings with fishery licensees to discuss fishery research, management, compliance and specific issues affecting the fishery (e.g. marine park planning). These management meetings underpin the decision-making process at a fishery-specific level. These meetings are generally coordinated by WAFIC (under a SLA), with the location, timing and priority of the Annual Management Meeting (AMM) determined by the WAFIC Industry Consultation Unit in liaison with relevant Departmental resource managers.

AMMs are attended by Department officers, WAFIC and licence holders and can occur at any time during the year, in accordance with the schedule as agreed by WAFIC and the Department. The AMMs may also be open to other stakeholder groups (e.g. Recfishwest, processors, universities, other government departments, the conservation sector and the general public) following consultation with industry.

The AMMs are widely-recognised by the commercial licence holders as a mechanism for receiving the most up-to-date scientific advice on the status of the fishery, facilitating information exchange and for discussing new and ongoing management issues. The invaluable local information licensees provide to the Department at these forums is considered when making research, management and compliance decisions.

12.2.3 Participation

The abovementioned consultation processes (both statutory and as required under the SLAs) undertaken by the Department ensures that stakeholders and the broader community have an increased awareness of, and access to, relevant information regarding fisheries management decisions. The Department encourages input from stakeholders and the broader community in the management process and facilitates their involvement by making all relevant information available and providing for discussion and the exchange of ideas.

WAFIC and Recfishwest are also responsible for seeking advice from their sector members during consultation periods and providing consolidated advice to the Department. Both organisations provide a monthly newsletter to subscribers, keeping them up-to-date with new initiatives, research results and issues. News and other relevant information is also publically-available on the WAFIC and Recfishwest websites.

Before making a decision around aquatic resource policy, the Minister must demonstrate that they have asked for, and taken into account, interested and affected parties' submissions on policy proposals. The release of Fisheries Management Papers (FMPs; discussion papers) for public comment are the most common way the Department undertakes wider consultation

and invites stakeholder engagement on fisheries management proposals. Published FMPs detail the recommended management approach arising out of an expert review process and seek public comment on those recommendations, which must be taken into account before a decision is made in respect to future management.

The Department encourages stakeholder comment in regard to any proposed management recommendations and publicises the release of FMPs. To ensure coverage and engagement during the consultation period with stakeholders and the wider community, the Department uses a variety of processes including:

- direct consultation in writing;
- publications in the *Government Gazette*;
- press releases;
- newspaper, radio and television interviews;
- dissemination of information via the Department's website; and
- invitations for stakeholders to sit on tasked working groups or participate in scientific reviews / workshops, formal risk assessment processes and management reviews.

The Department is currently reviewing its consultation processes to provide greater opportunity for stakeholder involvement. This may include public forums, targeted consultation with key interest groups, or a regional approach, depending on the fishery or issues under consideration.

12.3 Long-term Objectives

The Department's *Strategic Plan 2009 - 2018* (Phase 3 2013 – 2015)³⁸ outlines the overarching long-term objectives of the Department. These include:

- Sustainability – to ensure WA's fisheries and aquatic resources are sustainable and to provide services based on risk to ensure fish for the future and support the maintenance of healthy aquatic ecosystems;
- Community Outcomes – to achieve an optimum balance between economic development and social amenity in accordance with a framework to achieve sustainability;
- Partnerships – to promote effective strategic alliances and community stewardship; and
- Agency Management – deliver services on behalf of Government in accordance with the Department's statutory requirements to achieve effective and efficient use of resources to support the delivery of our strategy.

³⁸ http://www.fish.wa.gov.au/Documents/corporate_publications/strategic_plan_2009-2018_phase3.pdf

The Strategic Plan also sets out the strategies and key deliverables and different divisions of the Department that are responsible for delivery and is reviewed on a regular basis.

In accordance with the WA Government's *Fisheries and Aquatic Resource Policy* (see DoF 2012a), the Department's long-term objectives are explicitly set out in WA fisheries legislation to guide decision-making³⁹. The objectives are consistent with MSC Principles and Criteria and incorporate the precautionary approach (see below).

The broad scope of enabling legislation for aquatic resources in WA ensures that it:

- Manages all factors associated with fishing (in line with ESD and EBFM);
- Provides a clear basis for management of a whole biological resource (as opposed to just one sector);
- Gives effect to IFM by:
 - Creating head powers that can establish management strategies with clear biological outcomes for all sectors as required;
 - Establishing formal harvest allocations where these have been made; or
 - Describes the basis of informal allocations where these operate; and
- Clearly distinguishes between managed aquatic resources and fisheries with biological targets and socially-regulated fisheries.

Sections 3 and 4a of the FRMA set out the overarching long-term sustainability strategy for fisheries and the aquatic environment in WA. As outlined in section 3, the objects of the FRMA are to:

“(a) to develop and manage fisheries and aquaculture in a sustainable way and (b) to share and conserve the State’s fish and other aquatic resources and their habitats for the benefit of present and future generations.”

The FRMA outlines the following means to achieve these objectives, including:

- *“Conserving fish and protecting their environment;*
- *Ensuring that the impact of fishing and aquaculture on aquatic fauna and their habitats is ecologically-sustainable and that the use of all aquatic resources is carried out in a sustainable manner;*
- *Enabling the management of fishing, aquaculture, tourism that is reliant on fishing, aquatic eco-tourism and associated non-extractive activities that are reliant of fish and the aquatic environment;*

³⁹ see DoF (2010) for a description of how the general legislation integrates with the fisheries policy framework to achieve the long-term sustainability objectives.

- *Fostering the sustainable development of commercial and recreational fishing and aquaculture, including the establishment and management of aquaculture facilities for community or commercial purposes;*
- *Achieving the optimum economic, social and other benefits from the use of the fish resources;*
- *Enabling the allocation of fish resources between users of those resources, their reallocation between users from time to time and the management of users in relation to their respective allocations;*
- *Providing for the control of foreign interests in fishing, aquaculture and associated industries; and*
- *Enabling the management of fish habitat protection areas and the Abrolhos Islands reserve.”*

In addition, section 4a of the FRMA outlines the use of the precautionary principle in fisheries management:

“In the performance or exercise of a function or power under this Act, lack of full scientific certainty must not be used as a reason for postponing cost-effective measure to ensure the sustainability of fish stocks or the aquatic environment.”

The proposed new ARMA more explicitly incorporates broader ESD and biodiversity conservation goals, with objects to:

“(a) ensure the ecological sustainability of the State’s aquatic resources and aquatic ecosystems for the benefit of present and future generations; and (b) to ensure that the State’s aquatic resources are managed, developed and used having regard to the economic, social and other benefits that the aquatic resources may provide.”

Overarching and long-term fisheries and ecological sustainability strategies that specifically include a precautionary approach are being implemented by the Department through its EBFM framework (Fletcher *et al.* 2010). The EBFM process provides the basis for ensuring sustainable fisheries and ecosystem management and is an integral component of the Department’s annual planning cycle for assigning activity priorities (see Section 12.1.1.3.2).

Since 2004 the Department has been implementing a process to determine how fish resources can be best shared between commercial, recreational and customary fishers and aquaculture. As described in more detail in Section 4.4, the IFM policy (DoF 2009) is aimed at ensuring that WA’s aquatic biological resources remain sustainable by allocating shares to the sectors. As part of this process, the DG of the Department is required to approve a sustainability report for each fishery, which includes a clear statement on the recommended sustainable allowable harvest level.

The Department has developed effectiveness and efficiency indicators to show the extent to which the goal of conserving and sustainably developing the State’s aquatic resources is achieved. Performance against these indicators is reported annually in the Department’s

Annual Report. The Internal Audit Committee maintains and manages the Department's internal audit function on behalf of the DG. The committee assists the DG to identify and quantify risks that have the potential to impede the Department in achieving its goals, and to guide the development and implementation of risk-mitigation strategies.

In order to effectively deal with community expectations for aquatic resource management, the legislative objectives outlined above have been translated into clearly-defined operational arrangements and procedures for each resource / fishery in the form of a fishery- or resource-specific harvest strategy. The harvest strategy is used to implement adaptive and precautionary approaches to fisheries management and includes the identification of harvesting approaches, the establishment of precautionary reference points and harvest control rules that describe how fishing exploitation should be adjusted as a function of changes in abundance.

The harvest strategies for the finfish and blue swimmer crab resources of the PHE include fishery-specific objectives (see Section 13.2) that align with those prescribed under the FRMA (and proposed ARMA), as well as clear and specifically-articulated performance levels and the associated management actions designed to achieve these objectives.

12.4 Incentives for Sustainable Fishing

WA fisheries legislation, including that governing the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery, has policies and principles that provide social and economic incentives to fishers to fish sustainably and encourage a sense of stewardship towards the resource. These incentives include policies that attempt to provide stability and / or security for fishers by:

- Providing strategic or statutory management planning to give certainty about rules and goals of management. For example, the Department has a general practice of holding AMMs with licensees to discuss fishery research, management, compliance and other fishery-specific issues as they arise. These meetings are recognised by commercial licence holders as a mechanism for receiving the most up-to-date scientific advice on the status of the fishery, facilitating information exchange and discussing new and ongoing management issues.
- Providing for the clarification of roles, rights and responsibilities of the various stakeholders; for example, WAFIC is recognised by the WA Government as the key source of coordinated industry advice for the commercial fishing sector. WAFIC's responsibilities include coordinating Government funding for industry representation and taking a leadership role for matters that involve or impact on a number of fisheries or are of an industry-wide or generic nature.
- Providing for a participatory approach to management, research and other relevant processes. The WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery have well-defined management processes, which are enshrined in legislation / policy and practice. For example, the harvest strategies for the finfish and blue swimmer crab resources of the PHE were developed following internal

workshops, correspondence and consultation with licensees, WAFIC and Recfishwest.

- Providing rights of exclusion (limited entry) for the commercial fishing sector. The number of MFLs in the WCEMF Area 2 is limited to 11 (10 of which are also licenced to retain blue swimmer crabs using traps), which are fully transferable and permits crab licensees to trade (buy, sell or lease) traps before and during the season. These ‘access rights’ engender a sense of ownership of the resource and a commitment to long-term sustainability to protect their investment; and
- Providing industry the opportunity to optimise economic returns generated by the resource within a sustainable fishery framework.

There are also regular information updates and discussions with licensees and other stakeholders on research (including annual stock assessment and predicted catches), management and compliance arrangements for current and future seasons and issues that arise during the fishing season, including:

- Annual research, management and compliance meetings with stakeholders, particularly the licensees;
- *Ad hoc* research, management and compliance meetings during the season with the licensees and other stakeholders;
- A wide range of policy, research, management, educational, compliance and other publications on the Department website;
- Specific targeted education programs run by the Department’s Community Education Branch (CEB); and
- Information on the WAFIC and Recfishwest websites.

This information and interaction encourages stakeholders, particularly the licensees, to take a sustainable and responsible approach to fishing and to support the management arrangements that underpin orderly fishing and long term sustainability.

There is high acceptance by the commercial and recreational fishing sectors that well-managed and sustainable fisheries result in positive social and economic outcomes for the individual fishers, each sector as a whole and the broader community. This acceptance drives sustainable and compliant fishing behaviour by providing positive social and economic incentives, including:

- An opportunity to support the community through the provision of employment and demand for services and supplies;
- The operation of fisheries that result in both profit and lifestyle benefits; and
- A general understanding by the WA community that the commercial fishing industry acts with integrity and respect.

Compliance, research and management staff work together to monitor compliance with sustainable fishing arrangements, and the Department actively considers and reviews management policy and procedures to ensure they are not contributing to unsustainable fishing practices and will adjust the fishing arrangements if necessary.

There are no incentives for the fishers to fish unsustainably and community pressure to 'do the right thing' leads to a high level of compliance and community members report fishers who are seen to be fishing illegally to the Department or through Fishwatch.

13. Fishery-Specific Management System

This section focuses on the management system directly applied to the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery, including:

- Fishery-specific management objectives;
- The decision-making process used in the fisheries;
- The compliance and enforcement system and its implementation;
- Research planning and monitoring; and
- An evaluation of the performance of the management system in meeting the objectives of the fisheries.

13.1 Harvest Strategy

To assist stakeholders (e.g. peak bodies), advisory committees, tasked working groups, etc. in developing management advice for the Minster, the current harvest strategy and control rule framework for the the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery was developed in 2015 (DoF 2105a, b). In line with the Department's Harvest Strategy Policy (DoF 2015c), the harvest strategies for the finfish and blue swimmer crab resources of the PHE include:

- The long- and short-term fishery-specific management objectives;
- A description of the performance indicators used to measure performance against these objectives;
- Reference levels (targets, thresholds and limits) for each performance indicator; and
- Associated harvest control rules, which articulate pre-defined management responses designed to maintain each resource at target levels and achieve the management objectives for the fishery.

The harvest strategies also include summaries of the monitoring and assessment procedures for the collection and analysis of data to determine stock status and fishery performance, as well as a description of the management measures that have been adopted and how the specific operations for the fisheries may be adjusted in response to performance against each of the reference levels.

Consultation and decision-making processes, together with compliance measures are also included to ensure stakeholders are provided with a fully-transparent description of the key processes that are used to manage the fishery.

13.2 Fishery-Specific Objectives

The WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery has clear, specific long- and short-term objectives designed to achieve the outcomes expressed by MSC's Principles 1 and 2. These objectives are outlined in the harvest strategies

for the finfish and blue swimmer crab resources of the PHE, which have been approved by industry and are publically-available on the Department's website (DoF 2105a, b).

The fishery-specific management system contains a range of strategies (as described throughout the MSC Principle 1 and Principle 2 sections of this document) to meet these objectives, with sufficient monitoring in place to assess the extent to which each objective is being met.

13.2.1 Ecological Sustainability

The long-term ecological objectives for the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery are consistent with achieving the outcomes expressed in MSC Principles 1 and 2. They focus on ensuring the biological and ecological sustainability of all captured aquatic resources, as well as ensuring the fisheries does not result in serious or irreversible harm to any ecosystem components:

- 1) To maintain spawning stock biomass of the target species (i.e. sea mullet and blue swimmer crabs) at a level where the main factor affecting recruitment is the environment;
- 2) To maintain spawning stock biomass of each other retained species at a level where the main factor affecting recruitment is the environment;
- 3) To ensure fishing impacts do not result in serious or irreversible harm⁴⁰ to bycatch species populations;
- 4) To ensure fishing impacts do not result in serious or irreversible harm to ETP species populations;
- 5) To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function; and
- 6) To ensure the effects of fishing do not result in long-term serious or irreversible harm to ecological processes.

Long-term management objectives are typically operationalised as short-term (annual) objectives through one or more performance indicators that can be measured and assessed against pre-defined reference levels so as to ascertain actual performance. Thus, within the context of the long-term objectives, each fishery (commercial and recreational) has operational objectives to maintain each resource / component above the threshold level (and, where relevant, close to the target level), or rebuild the resource if it has fallen below the threshold or the limit levels.

Lists of the short-term objectives for the finfish and blue swimmer crab resources of the PHE are provided in Table 13.1 and Table 13.2, respectively.

⁴⁰ Serious or irreversible harm relates to a change caused by the fishery that fundamentally alters the capacity of the component to maintain its function or to recover from the impact.

Table 13.1. Short-term ecological objectives in place for each component of the finfish fishery in the PHE. The performance indicators and reference levels used to assess the extent in which the fishery has met these objectives is provided in the *Finfish Resources of the Peel-Harvey Estuary Harvest Strategy*.

Component	Short-term Operational Objectives
Target species: Sea mullet	<ul style="list-style-type: none"> • Annual standardised commercial catch rate is within target catch rate range; and • Annual commercial catch is within target catch range.
Other retained species: Yelloweye mullet, yellow-fin whiting, Australian herring and tailor	<ul style="list-style-type: none"> • Annual commercial catch of each species is less than maximum catch of that species observed during the reference period; and • Fishing impacts generate an acceptable level of risk to retained species stocks (i.e. moderate risk or lower).
Cobbler	<ul style="list-style-type: none"> • Annual catch rate is greater than 6 kg / fishing day; • Annual commercial catch is less than maximum catch of cobbler observed during the reference period (i.e. 9 tonnes); and • Fishing impacts generate an acceptable level of risk to cobbler stocks (i.e. moderate risk or lower).
Perth herring	<ul style="list-style-type: none"> • Annual commercial catch is less than maximum catch observed during the reference period (i.e. 2.7 tonnes); and • Fishing impacts generate an acceptable level of risk to Perth herring stocks (i.e. moderate risk or lower).
All other retained species	<ul style="list-style-type: none"> • Annual commercial catch of each other retained species is < 5 % of the total retained catch; and • Fishing impacts generate an acceptable level of risk to all other retained species stocks (i.e. moderate risk or lower).
Bycatch	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable risk level to all bycatch species populations (i.e. moderate risk or lower).
ETP species	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable risk level to all ETP species populations (i.e. moderate risk or lower).
Habitats	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable risk level to habitat structure and function (i.e. moderate risk or lower).
Ecosystem	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable risk level on ecological processes within the estuary (i.e. moderate risk or lower); and • Fishing impacts generate an acceptable risk level for each ecological resource / asset within the PHE (i.e. moderate risk or lower).

Table 13.2. Short-term ecological objectives in place for each component of the blue swimmer crab fishery in the PHE. The performance indicators and reference levels used to assess the extent in which the fishery has met these objectives is provided in the *Blue Swimmer Crab Resource of the Peel-Harvey Estuary Harvest Strategy*.

Component	Short-term Operational Objectives
Target species: Blue swimmer crab	<ul style="list-style-type: none"> • Annual standardised commercial catch rate is within target catch rate range (i.e. 0.7 – 1.4 kg / traplift); and • Annual commercial catch is within target catch range (i.e. 45 – 104 tonnes).
Other retained species	<ul style="list-style-type: none"> • Annual catch of each species is < 5 % of the total retained catch for each fishing sector; and • Fishing impacts generate an acceptable level of risk to retained species stocks (i.e. moderate risk or lower).
Bycatch	<ul style="list-style-type: none"> • Annual catch of each species is < 5 % of the total catch for each fishing sector; and • Fishing impacts generate an acceptable level of risk to bycatch species populations (i.e. moderate risk or lower).
ETP species	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable level of risk to ETP species populations (i.e. moderate risk or lower).
Habitats: Benthic habitats — commercial trap and recreational drop net Nearshore habitats — recreational scoop net	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable level of risk to habitat structure and function (i.e. moderate risk or lower).
Ecosystem Processes	<ul style="list-style-type: none"> • Fishing impacts generate an acceptable level of risk to ecological processes within the estuary; and • Fishing impacts generate an acceptable level of risk to ecological resource / asset within the PHE (i.e. moderate risk or lower).

13.2.2 Social and Economic Objectives

As discussed in Section 12.3, one of the long-term objectives of the FRMA is to achieve the optimum economic and social and other benefits from the use of fish resources for both direct stakeholders (e.g. the commercial fishing industry, recreational fishers, customary fishers, conservation sector) and indirect stakeholders (e.g. the tourism sector, fishing tackle suppliers, restaurants and retail sector, consumers and the wider WA community). In line with the Department's Harvest Strategy Policy (DoF 2015c) and the principles of ESD, the PHE fisheries also have explicit long-term social and economic objectives in place.

As outlined in full in the harvest strategies for the finfish and blue swimmer crab resources of the PHE (see DoF 2015a, b), the social and economic objectives for these fisheries relate to the provision of opportunities to ensure (1) commercial fishers can maximise their livelihood in supplying seafood to the community and (2) that all fishers can maximise cultural,

recreational and / or lifestyle benefits of fishing. Performance against the objectives is generally monitored through the formal consultation process in place, in which regulatory impediments to maintaining social and economic returns, or opportunities for enhancing these, are discussed. Where possible, and in due consideration of ecological sustainability, fisheries management arrangements can be adjusted or reformed to help meet these objectives.

As the commercial and recreational fishing sectors are provided formal access rights to the blue swimmer crab resource of the PHE through IFM, performance against the second of the above objectives is also measured for blue swimmer crabs by comparing the catches of this species by each sector against their allowable catch ranges⁴¹ (DoF 2015b).

It is important to note that management actions relating to social and economic objectives are applied within the constraints of ecological sustainability and that fisheries managers cannot always address the causes of constraints on access to fishing activities, as these may be due to environmental or other factors.

13.3 Decision-Making Processes

There are established decision-making processes in the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery that result in measures and strategies to achieve the objectives listed above in Section 13.2. These processes are understood by all stakeholders and underpinned by explicit and transparent consultation.

Decision-making processes can also be triggered following the identification of new or potential issues as part of an ecological risk assessment (generally reviewed every 3 – 5 years), results of research, management or compliance projects or investigations, monitoring or assessment outcomes (including those assessed as part of the Harvest Strategy) and / or expert workshops and peer review of aspects of research and management, e.g. the 2010 external review of the blue swimmer crab fishery in the PHE (see Appendix C).

Once an issue has been identified, mitigation measures are developed and implemented in consultation with industry. Alternatively, if appropriate, additional research may be undertaken, with research results used to inform management action. There are two main processes for making decisions about the implementation of management measures and strategies in the the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery:

- Annual decision-making processes that may result in measures to meet the short-term fishery objectives (driven by the control rules contained in the harvest strategies); and
- Longer-term decision-making processes that result in new measures and / or strategies to achieve the long-term fishery objectives (i.e. changes to the management system).

However, if there is an urgent issue, stakeholder meetings may be called to discuss the issue and determine appropriate management action, as needed.

⁴¹ The sectoral catch ranges may be reviewed in line with the final allocation determinations.

13.3.1 Annual Processes

The harvest strategies for the finfish and blue swimmer crab resources of the PHE guide management responses in the event that a short-term objective is not met (i.e. the performance indicator is not maintained above the threshold reference level following an annual assessment).

In the case that a performance indicator has breached a threshold level but not reached the limit level, the harvest control rules require research and management staff to undertake a review of the reasons for the variation. This review includes an investigation of any changes that may have taken place in the fishery (e.g. targeting, methods, gear, seasonality, etc.), environmental factors, such as variations in weather or water temperature, or other external factors, such as changes in any market forces that influence fishing effort (e.g. fuel prices, demand, etc.). This review may be undertaken in conjunction with the licence holders, as they provide many of the details needed during the review process (e.g. changes in effort).

The outcomes from the previous season's assessment against the defined reference levels (including any additional reviews undertaken as described above) are provided to industry by the Department at the AMM. It is at this stage that any issues arising from the annual evaluation of the fishery's performance are discussed. Where sustainability is considered to be at risk, stakeholder meetings will be called to discuss the issue and appropriate changes to the management arrangements to be implemented for the following fishing season.

While this has not occurred in the PHE, an example of such a process can be taken from the blue swimmer crab fishery in nearby Cockburn Sound. Stakeholders were advised at the AMM in December 2013 that there were concerns about the sustainability of the resource (i.e. for a different stock to that in the PHE). Between December 2013 and March 2014, the Department conducted a review of available data from commercial monitoring and fishery-independent surveys, with results confirming poor levels of recruitment and a decrease in catch rates and overall catch. This information was provided to stakeholders and the commercial fishery was voluntarily closed in April 2014, after the catch rates reached a limit of 0.5 kg/trip lift in March 2014. The blue swimmer crab recreational fishery in Cockburn Sound was closed in May 2014⁴².

13.3.2 Long-Term Processes

There is also an established decision-making process in place to ensure the long-term management objectives are met. This process is triggered primarily as a result of analysing longer-term patterns or trends in the annual fishery performance. Variations in the operating environment caused by other factors (e.g. environmental conditions, market forces, fishing behaviour, conflicts with other user groups, marine planning, etc.) can also trigger an investigation and discussion that may lead to more-permanent changes (i.e. lasting more than one season) in the management system.

⁴² See <http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Early-closure-of-Cockburn-Sound-crab-fishery.aspx>

Longer-term changes are often implemented in legislation. The decision-making process that results in changing legislation involves a high level of consultation with industry and other stakeholders that may be affected by the change. In developing management options, consultation is undertaken with affected parties and relevant experts through a number of mechanisms, including:

- Directly in writing;
- At licensee meetings;
- At internal workshops, e.g. harvest strategy development, compliance risk assessments;
- Through the establishment of a tasked working group; and / or
- As part of external / expert workshops (e.g. risk assessments).

These forums are used to work through options for addressing emerging issues and provide the opportunity for decision-makers to consider all interested stakeholder advice. Comments provided during this process also allow managers to take into account the broader implications of management options.

Following this consultation process, any new proposed management measures or strategies that require changes to legislation or publication are provided to the statutory decision-maker (usually the DG or the Minister) by the relevant Departmental aquatic management staff.

For example, at the July 2012 AMM for the WCEMF, the MLFA requested an extension to the permitted operational hours in the PHE to allow sufficient time to retrieve gear during periods of bad weather conditions. After noting this request, the Department consulted with Recfishwest and received support for the proposed changes. The Department forwarded advice and recommendations to the Minister seeking approval to amend the interim management plan to change the operational hours in the fishery. The Minister approved these recommendations and consequently the management plan was amended prior to the AMM held in October 2013.

13.3.3 Responsiveness of Processes

The governance system in place allows for a timely response in instances where management changes need to be applied to alleviate unacceptable risks to stocks. The timing of provision of scientific advice on the status of stocks is concomitant with the risk levels for particular species, thus it varies between different fisheries. However, once advice is received, there is a prompt process to review this advice for scientific rigour and develop management actions.

For example, following community concerns about a potential shift in recreational fishing effort for blue swimmer crabs to the PHE (and other nearby areas) after the closure of the fishery in Cockburn Sound in 2006, the recreational fishing bag and boat limits for this species in the WCB were halved to 10 blue swimmer crabs per person and 20 crabs per boat. The effectiveness of this management change in reducing catch is evident from data collected in the 2007/08 recreational fishing survey in the PHE, demonstrating that just under half of

boat fishers caught the new boat limit of 20 crabs in the peak fishing months of January-March.

Section 43 of the FRMA provides the power for immediate action by allowing the Minister for Fisheries to prohibit fishing activities (i.e. close an area to fishing) or prohibit a specific fishing activity (i.e. trap fishing) should information come to hand that indicates an unacceptable risk. Should immediate action be required, section 65(4) of the FRMA provides for the Minister to amend a management plan without consultation if, in the Minister's opinion, the amendment is required urgently or is of a minor nature (but must provide advice following the amendment of the plan).

13.3.4 Use of Precautionary Approach

The EBFM process used by the Department provides the operating basis for implementing sustainable fisheries and ecosystem management by identifying ecological assets in a hierarchical manner and identifying the risks associated with them. Thus, the levels of knowledge needed for each of the issues only need to be appropriate to the risk and the level of precaution adopted by management.

Where reliable stock status information is lacking, the reference levels for captured resources and / or other ecological components have been set at precautionary levels. For example, the reference levels for bycatch species have been set to reflect the outcomes of periodic (every 3 – 5 years) risk assessments. The target reference level is that fishery impacts generate an acceptable risk level (e.g. moderate risk or lower [as per Fletcher 2005]). However, should substantial changes to fishery operations or management be introduced, a review of the risk levels is undertaken to determine any changes in the risk to bycatch species. Where fishing impacts are considered to be at an unacceptable risk level (e.g. high risk or above), appropriate management strategies will be implemented to reduce the risk back to an acceptable level.

The control rules in place for the finfish and blue swimmer crab resources of the PHE (as per the harvest strategies) also incorporate a precautionary approach into the decision-making process by requiring a review of the fishing activities and management arrangements when a threshold reference level is breached (i.e. prior to reaching the limit level). The use of a threshold level provides for an inherent 'warning system', with any potential issues recognised, investigated and potentially addressed while in their early stages. The frequency of evaluation (annual) and review allows for management action to alleviate adverse impacts before a limit level is reached and long-term sustainability may be compromised. An example of this can be seen in the recent closure of the Cockburn Sound blue swimmer crab fishery (see Section 13.3.1).

13.3.5 Accountability and Transparency

The Department is required to provide evidence of consultation and the results of the decision-making processes. This evidence is usually provided in the form of formal

Departmental publications and is made available on the Department's website⁴³. The implementation of any new statutory arrangements must also be formally communicated to the licence holders and other stakeholders in writing.

The Department regularly reports to key stakeholders on annual fishery performance, including information on fishery outcomes, management actions and relevant findings and recommendations from research, monitoring, evaluation and review activities. This information is primarily provided to licence holders and other stakeholders at the AMMs. Comprehensive information on each of the State-managed fishery's performance, management system and actions, research, monitoring, and other activities are also compiled regularly and published in a number of publically-available documents, including:

- The annual *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher & Santoro 2014);
- The Department's *Annual Report* to Parliament;
- The *Research, Monitoring, Assessment and Development Plan* (e.g. DoF 2012b; currently being updated); and
- Fisheries Management Papers (FMPs), Fisheries Research Reports (FRRs), Fisheries Occasional Papers (FOPs) and peer-reviewed scientific journal articles. For example:
 - FRR No. 258: "*Assessment of the blue swimmer crab recruitment and breeding stock levels in the Peel-Harvey Estuary and status of the Mandurah to Bunbury Developing Crab Fishery*" (Johnston *et al.* 2014a).

All of the fishery-specific management information, including the FRMA, FRMR, the *WCEMF Management Plan* and the harvest strategies for the finfish and blue swimmer crab resources of the PHE are also publically available on the State Law Publisher and the Department's websites.

Examples to demonstrate transparency of decision-making relevant to the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery are provided in Table 13.3 and Table 13.4.

⁴³ All post-2010 publications available at: <http://www.fish.wa.gov.au/About-Us/Publications/Pages/default.aspx>

Table 13.3. Progress of decision-making undertaken as the WCEMF moved from an interim managed to a managed fishery in 2013 – 2014 (as required by the FRMA)

Timing	Developments
Apr 2013	The Minister for Fisheries approves the transitioning of the West Coast Estuarine (Interim) Managed Fishery to a managed fishery on 24 April and instructs the Department to initiate this process as soon as possible.
May 2013	<p>Department writes to all commercial licence holders, the MLFA, WAFIC and Recfishwest on 15 May 2013 to advise these stakeholder of the above developments.</p> <p>The Department advises all commercial licence holders that, in order to establish a new management plan by 30 June 2014, all substantive changes to the management of the fishery will be deferred until the new plan commences. The only significant change to the new plan was to increase in the scope of the fishery to incorporate Hardy Inlet and its sole fisher into the managed fishery⁴⁴. The majority of other changes from the interim plan to the new plan were administrative in nature.</p> <p>Licence holders were given until the end of May 2013 to provide their views on the matters raised in the letter, while peak stakeholder bodies were provided with the opportunity to put forward their views by 7 June 2013.</p>
Oct 2013	New management plan discussed at AMM and licence holders agree with new management arrangements. Notice published in the Government <i>Gazette</i> on 29 October 2013 ⁴⁵ advising that draft management plan is available for comment and public comment period will expire on 29 November 2013.
Jan 2014	All comments received during the public comment period were forwarded by the Department to Minister with advice and recommendations seeking approval of the new plan and revocation of interim plan (allowing six weeks for Minister's consideration and approval).
Mar 2014	<p>The new <i>West Coast Estuarine Managed Fishery Management Plan 2014</i> is approved by the Minister on 14 March 2014 and published in the Government Gazette on 25 March 2014⁴⁶.</p> <p>All of the permit holders continued to operate under the Interim Plan until the 30 June 2014 when it expired and ceased to exist. The new Plan came into effect on 1 July 2014. All interim managed fishery permit holders were invited to apply for WCEMF licences and were given until the 30 April 2014 (as specified in Clause 6 of the new management plan) to submit all applications to the Department.</p>
May 2014	All licence holders advised whether the Department intended to grant them a new WCEMF licence along with a request for the prescribed Managed Fishery Licence (MFL) fees. Upon receipt of the prescribed fee each applicant was issued with a new WCEMF licence.
Jul 2014	The new Management Plan came into effect. The Interim Management Plan expired and ceased.
2015	The Department will consult with WCEMF licence holders, and Recfishwest (as appropriate), in early 2015 regarding any outstanding or other policy matters with a view to amending the new management plan to address those matters later in 2015.

⁴⁴ The operator in the Hardy Inlet previously fished under an Exemption from the provisions of Schedule 2, Item 4 (a) of the *Closed Waters Professional Netting (Rivers, Estuaries, Inlets and Lakes South of 23° South Latitude) Notice 1992*.

⁴⁵ [http://www.slp.wa.gov.au/gazette/gazette.nsf/lookup/2013-192/\\$file/gg192.pdf](http://www.slp.wa.gov.au/gazette/gazette.nsf/lookup/2013-192/$file/gg192.pdf)

⁴⁶ [http://www.slp.wa.gov.au/gazette/GAZETTE.NSF/searchgazette/DD6423342923A56448257CA5000CDBA0/\\$file/Gg046.pdf](http://www.slp.wa.gov.au/gazette/GAZETTE.NSF/searchgazette/DD6423342923A56448257CA5000CDBA0/$file/Gg046.pdf)

Table 13.4. Process of decision-making undertaken as changes were made to recreational fishing rules in WA.

Timing	Developments
Feb 2012	<p><i>A Resource-based Management Approach for Recreational Fishing in Western Australia 2012 – 2017</i> (DoF 2012c) was released for public comment until 30 April 2012.</p> <p>As the peak body representing recreational fishers, Recfishwest was responsible for arranging and facilitating regional consultation (including a meeting at the Mandurah Offshore Fishing and Sailing Club) on the proposed strategy. Recfishwest advised that it received over 900 public submissions.</p>
Dec 2012	New statewide recreational fishing rules were announced.
Feb 2013	The new statewide recreational fishing rules (DoF 2014a) came into effect.

13.3.6 Approach to Disputes

The decision-making process for the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery proactively avoids legal disputes through the inclusion of and consultation with stakeholders when making changes to key management matters. This allows for all impacts of proposed management actions to be considered and for the resolution of conflicts through negotiation and compromise.

Should a dispute arise, there are well-established mechanisms for administrative and legal appeals of decisions (see Section 12.1.2). Disputes regarding statutory validity are dealt with by the Courts, which tests the validity of legislation. These mechanisms have been used and tested across several fisheries, for example:

- Shine Fisheries Pty Ltd vs Minister for Fisheries 2002⁴⁷. This judgement was put into effect by permitting full transferability in the West Coast Estuarine (Interim) Managed Fishery, where previously there had been limited opportunities for transferability, and allowing the nominated operator of a vessel to be changed.
- Edgemere Pty Ltd vs Minister for Fisheries & Anor 1997⁴⁸. This judgement examines an appeal by a fisherman to gear restrictions imposed in the Abrolhos Islands trawl fishery, where the judge found in favour of the Department.

13.4 Compliance and Enforcement

To optimise the use of compliance resources, enforcement effort is designed to maximise the potential for fishers to voluntarily comply with fishery rules, while providing a reasonable

⁴⁷<http://decisions.justice.wa.gov.au/supreme/supdcns.nsf/judgment.xsp?documentId=89CBEA251EC082BB48256B5A000C1635&action=openDocument>

⁴⁸<http://decisions.justice.wa.gov.au/supreme/supdcns.nsf/judgment.xsp?documentId=E2B71DECD36F4C1B48256497004CD3F9&action=openDocument>

threat of detection, successful prosecution and significant penalties for those who do not comply. This is achieved through a range of strategies, including effective monitoring and surveillance, appropriately trained staff, suitable deterrents in the forms of fines and administrative penalties and targeted educative campaigns.

The Department's Regional Services Division (RSD) delivers the Department's compliance and educational services, with the support of the Communications and Education Branch. There are approximately 170 RSD staff across the State, spread throughout regional and district offices. Regional operational areas are supported by the Regional Services Branch's Perth-based Central Support Services and Strategic Policy sections.

Key compliance programs in place throughout the State include:

- Recreational fishing;
- Commercial fishing;
- Biosecurity;
- Pearling and Aquaculture;
- Marine parks (State and Commonwealth);
- Fish Habitat Protection Areas (FHPAs);
- Marine Safety; and
- Organised, unlicensed fisheries crime.

Compliance and community education services for fisheries in the WCB (including the PHE) are delivered by Fisheries and Marine Officers (FMOs), Community Education Officers and associated management and administrative support staff based at WCB regional offices, statewide mobile patrol units and officers aboard the large, ocean-going patrol vessels PV Houtman and Walcott. During 2012/13, the WCB FMOs delivered a total of 24 428 hours of compliance and community education services in the field (Fletcher & Santoro 2014).

Most FMOs are permanently located in the main population centres with access to appropriate platforms to allow them to undertake patrols up and down the entire WA coastline. A small number of officers are also specifically employed to undertake mobile patrols to conduct 'surprise' inspections, an activity that is particularly important in smaller towns where fishers can quite easily learn the movement patterns of local officers (Green & McKinley 2009).

FMOs undertake regular land, air and sea patrols using a compliance delivery model supported by a risk assessment process and associated operational planning framework. Services provided by the land-based officers include processing inspections, landing and gear inspections, licensing checks, wholesale / retail checks and sea-based patrols utilising vessels ranging in size from five to 12 metres. They also provide support to seagoing personnel and provide a wide variety of education and extension services through formal and informal media to commercial and recreational fishers, fishing-related operations

(wholesale / retail / processors), other resource management agencies and community members (Fletcher & Santoro 2014).

The Department also delivers at-sea marine safety compliance services on behalf of the Department of Transport in the Metropolitan Region extending from Mandurah to Lancelin (excluding the Swan and Canning Rivers). Outside of this area, marine safety is unfunded, and inspections are carried out in combination with fisheries compliance inspections. Marine park education and compliance functions are also undertaken in the Ngari Capes Marine Park (South West), Shoalwater and Marmion Marine Parks (Metropolitan) and Jurien Bay Marine Park (Midwest). These functions are primarily related to the integrity of management arrangements for the different zoning within the marine parks (Fletcher & Santoro 2014).

13.4.1 Monitoring, Control and Surveillance Implementation

Monitoring, control and surveillance (MCS) mechanisms ensure fisheries management measures are enforced and complied with. There is a comprehensive MCS system implemented in the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery that has demonstrated a consistent ability to enforce relevant management measures, strategies and / or rules. The MCS system for these fisheries is administered by the Department's RSD through fishery-specific Operational Compliance Plans (OCP; see Section 13.4.1.2 below).

13.4.1.1 Compliance Risk Assessments

Ongoing annual or seasonal review of compliance service delivery in the PHE is undertaken using a compliance risk assessment process, which may involve the participation of management, field-based FMOs, researchers, commercial and recreational fishers, fish processors and representatives from other interested stakeholder groups. The risk assessment process feeds into an OCP⁴⁹, which provides the formal framework for the delivery of specific compliance services that remove or mitigate identified risks.

The compliance risk assessment process identifies modes of offending, compliance countermeasures and risks and relies on a weight-of-evidence approach, considering information available from specialist units, trends and issues identified by local staff and Departmental priorities set by the Aquatic Management Division through Fish Plan. The risk assessment process can also be triggered by the introduction of new supporting legislation⁵⁰ in a fishery / resource or the identification of any new major issues that would require RSD managers to assess their compliance program including (but not limited to):

- A sectoral complaint;
- Ministerial or Parliamentary enquiry;
- Management framework issues;
- Public complaint or sustained media interest;

⁴⁹ By their nature, OCPs contain sensitive information and are only made available to authorised compliance personnel.

⁵⁰ Supporting legislation refers to any legislation that would allow non-compliance with the management framework to be detected and prosecuted with a reasonable chance of securing a conviction.

- Intelligence; or an
- Upward trend in non-compliance.

13.4.1.2 Operational Compliance Plans

An OCP provides a formal and transparent process for staff to carry out defined compliance activities in order to monitor, inspect and regulate the compliance risks to each specific high-risk activity in a fishery, and in turn confirm they are at an acceptable and manageable level. This is supported by measurable reporting methods defined under the OCP to demonstrate compliance activities being undertaken are having a direct and significant impact on reducing identified risks.

OCPs are available for both the commercial and recreational sectors in the PHE. The development of an OCP consists of identifying and applying tailored compliance strategies for each identified risk. In the case of the WCEMF (Area 2) and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery, this includes strategies that may deal with identified high risks related to seasonal considerations, spatial considerations, environmental considerations and identified persons or groups of interest.

Each OCP is reviewed following a compliance risk assessment. By regularly reviewing the OCPs for both commercial and recreational fishing sectors in the PHE, rational and accountable decisions can be made about deploying compliance resources and ensuring that resources are available to mitigate risks to an acceptable level. Following a formal review of a fishery's OCP and associated compliance strategies, compliance activities are prioritised in accordance with risk, budget and resourcing considerations. The recreational and commercial sector OCPs for the PHE were reviewed and updated during 2014/15.

Annual planning meetings are held for OCPs, with regular specific planning of day-to-day targeted and non-targeted patrols linked to the OCP based on resources and competing priorities.

13.4.1.2.1 Resourcing Compliance Operations

RSD staff at the Mandurah Regional Office co-ordinate the allocation and prioritisation of existing resources across all programs in the region based on risk assessments and related OCPs for each program. Compliance planning meetings are held regularly to ensure staffing requirements are adequate for scheduled compliance activities.

Available compliance resources are allocated based on the risk assessment outcomes and the contacts and compliance statistics which are captured, reported on and reviewed at the end of each year. The allocated resources and compliance strategies (i.e. monitoring, surveillance and education activities) are outlined in the OCP, which specifies planned activities and staff allocated to key compliance tasks and duties. This planning and delivery process allows for more targeted, effective and relevant compliance service in terms of both cost and activities.

There is also flexibility within the region to allocate additional resources to respond to changes, such as the need for a planned tactical operation in response to new intelligence.

This may be achieved by redirecting existing resources or seeking additional resources from other areas or units. Similarly, changing priorities and resourcing on a local level can involve reducing planned delivery of compliance services to ensure resources are directed to where they are most needed.

13.4.1.2.1.1 Key Compliance Personnel

Staff located at Mandurah Regional Office provide the primary on-ground compliance and education delivery for the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery. Key compliance and enforcement personnel located in the region and their responsibilities include:

1. Compliance Manager

- High-level management of all compliance resources within the region and overall responsibility for OCPs and compliance strategies, including their development, review and ensuring outcomes are delivered;
- Ensuring FMO safety is considered at all times and the region's occupational health and safety requirements are met;
- Managing all prosecution briefs and determines all matters progressing to Court;
- Ensuring compliance with with the *Standard Operating Procedures, Prosecution Guidelines*⁵¹; and
- Overseeing all Investigation Plans.

2. Supervising Fisheries and Marine Officers

- Field responsibility for OCPs and strategies, including reporting any deficiencies and reporting the outcomes as they are delivered or achieved;
- Managing the issue of all infringement notices and infringement warnings;
- Ensures compliance with Prosecution Policy Guidelines;
- Managing Investigation Plans;
- Liaising with staff from other agencies operating in a joint servicing arrangement;
- Ensuring that Fishwatch complaints are followed up; and
- Ensuring information reports are entered into the Intelligence database.

⁵¹ The *Prosecution Guidelines* is a confidential guide used by FMOs that provide a tiered framework for dealing with fishery offences, thus it is not a publically-available document.

3. Fisheries and Marine Officers (FMOs):

- Day-to-day responsibility for the execution of the OCPs, including delivery of planned and routine compliance monitoring, control and surveillance activities;
- Case officers in Investigation Plans; and
- Issuing infringement notices, warnings and prosecution briefs through eBrief.

FMOs are formally appointed pursuant to the FRMA, which clearly sets out their powers to enforce fisheries legislation, enter and search premises, obtain information and inspect catches. FMOs are highly trained they; must have a thorough knowledge of the legislation, are responsible for enforcing and following a strict protocol for undertaking their duties in accordance with FRMA and record information relating to the number and type of contacts, offences detected and sanctions applied.

In addition to regional compliance staff, there are a number of units within the Department that support the delivery of compliance outcomes, including:

1. Serious Offences Unit

- Undertakes covert operations and deals with connections to organised crime;
- Conducts major investigations and initiates proactive intelligence-driven operations;
- Targets any serious and organised criminal activity within the fishing sector;
- Provides specialist investigative training; and
- Provides technical assistance in relation to covert surveillance.

2. Fisheries Intelligence Unit

- Responsible for providing intelligence reports to support strategic, operational and tactical needs of compliance programs; and
- Collects and analyses compliance data.

3. Compliance Statistics Unit

- Develop monitoring and sampling programs to support compliance delivery;
- Collects and analyses compliance data to identify trends; and
- Provides compliance statistics to help target enforcement activities.

4. Prosecutions Unit

- Manages the electronic system used to issue infringement notices or commence prosecution processes when offences are detected; and
- Custodians of information relating to detected offences which can be used for official reporting purposes.

5. Vessel Monitoring System (VMS) Unit (Note VMS is not used in the WCEMF)

- Operates the Department's vessel monitoring system (VMS) to help manage the State's commercial fisheries.

6. Strategic Policy Section of the Regional Services Branch

- Develops and implements strategic compliance policy and standards;
- Provides compliance risk assessments for fisheries;
- Provides review and implementation of fisheries management and compliance legislation;
- Oversees collection and analysis of compliance data;
- Oversees compliance research projects;
- Develops occupational health and safety standards for FMOs; and
- Provides recruitment and training of new and existing FMOs.

13.4.1.3 Formal MCS Systems

A wide range of compliance tools are used by the RSD to ensure that commercial and recreational fishers in the PHE are complying with fisheries legislation.

13.4.1.3.1 Monitoring Activities

FMOs deliver compliance activities directed at commercial and recreational fishers in the PHE via:

- On-water enforcement (by three dedicated compliance vessels, e.g. checking for interference with commercial fishing gear by unauthorised people);
- Land-based enforcement (at landing locations);
- Recreational mobile patrols that operate along the shores of the estuary;
- Road-side check points (in collaboration with the WA Police) for protected species (e.g. undersize fish / crabs or berried female crabs);
- Processor factory inspections of catches;
- Wholesale retail inspections of catches; and
- Attending industry meetings.

Compliance of the commercial fishing sector is monitored via both on water and on-land inspections, with the majority of checks being carried out at the point of landing (i.e. boat ramps). For the commercial licence holders, these inspections focus on checking that:

- The vessel and fisher hold current Department authorisation and have a valid commercial fishing licence;
- The gear used by the operator complies with relevant requirements;
- The operator is compliant with minimum legal size and protected fish requirements (e.g. berried crabs);
- No bycatch has been retained (e.g. blue swimmer crabs when fishing using haul and gillnets); and
- There is no fishing in closed areas.

Recreational fishing activities occurring within the PHE include:

- Recreational crabbing from boats;
- Recreational crabbing from shore;
- Recreational diving;
- Recreational net fishing (Wednesday nights only);
- Recreational prawn fishing; and
- Recreational line fishing.

Compliance of the recreational fishing sector is monitored via on-water and on-land inspections, both through checks at points of landing (boat ramps) and along the foreshore area of the PHE. The inspections focus on checking that recreational fishers:

- Are compliant with minimum legal size and protected fish requirements (i.e. berried crabs), and bag / boat limits (e.g. 10 blue swimmer crabs per person, 20 crabs per boat if more than one person is in the boat, and 30 mullet [Family Mugilidae] per person);
- Are compliant with seasonal closure and daily time restrictions;
- If relevant, hold a current RFBL when fishing from a boat or a RNFL when recreational net fishing;
- Use gear compliant with relevant requirements; and
- Do not retain any totally protected species.

13.4.1.3.2 Control Mechanisms

Fisheries legislation forms the main component of the control system for commercial and recreational fisheries in WA. A summary of the control measures in place in the WCEMF and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery are provided in Table 13.5 and Table 13.6, respectively.

Table 13.5. Management measures and instrument of implementation for the West Coast Estuarine Managed Fishery: Area 2.

Measure	Description	Instrument
Limited Entry	A limited number of Managed Fishery Licences (11) are permitted to operate in the Peel-Harvey Estuary, with 10 of these licensees permitted to catch blue swimmer crabs.	WCEMF Management Plan
Effort Restrictions	The capacity of Area 2 of the WCEMF is 12 000 m of haul net, 12 000 m of set net and 420 traps. No more than 1 000 m (total combined length) of set nets and haul nets can be used in Area 2 of the fishery at any one time.	WCEMF Management Plan
Gear Controls	Restrictions on overall net size, mesh size and set depth for set and / or haul nets. Blue swimmer crabs can only be targeted using crab traps, with restrictions on size and internal volume.	WCEMF Management Plan
Seasonal Closure	The PHE is closed to fishing for blue swimmer crabs between 1 September and 31 October.	WCEMF Management Plan
Temporal Closures	Specific weekend and daytime closures.	WCEMF Management Plan
Spatial Closures	Parts of Peel-Harvey Estuary are permanently closed to commercial fishing activities to preserve sensitive habitats that are important for bird species.	WCEMF Management Plan
Condition and Size Limits	Species-specific size limits are in place for some finfish species and for blue swimmer crabs (miminum size limit of 127 mm CW). No retention of berried female crabs.	FRMR
Reporting	Fishers are required to report all retained species catches, effort, ETP species interactions and fishing location in statutory monthly logbooks.	FRMR

Table 13.6. Management measures and instrument of implementation for the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery.

Measure	Description	Instrument
Effort Restrictions	Maximum of 10 drop nets per person and per boat.	FRMR
Gear Controls	Blue swimmer crabs can only be caught by hand or using blunt wire hooks, drop nets or scoop nets.	FRMR
Seasonal Closure	The fishery is closed to fishing between 1 September and 31 October.	Prohibition on Fishing for Crabs (Peel Inlet and Harvey Estuary) Order 2007
Condition and Size Limits	Minimum size limit of 127 mm CW for blue swimmer crabs. No retention of berried female crabs.	FRMR
Bag and Boat Possession Limits	Daily limit of 10 blue swimmer crabs per person and 20 blue swimmer crabs per boat (two or more Recreational Boat Fishing Licences required to take boat limit).	FRMR

13.4.1.3.3 Surveillance Activities

The majority of surveillance activities in the PHE are undertaken by FMOs during field-based patrols. FMO's follow a variety of established Standard Operating Procedures (SOPs) when undertaking patrol and inspection work. These procedures ensure that inspections are carried out safely, efficiently, correctly and with due regard to relevant policies. SOPs also ensure consistency in the delivery of compliance services and the ability to quickly familiarise new staff to the specifics of important compliance elements in a fishery.

Compliance activities undertaken during patrols are recorded and reported by FMOs using a daily patrol contact (DPC) form (Appendix G). The purpose of these forms is to record and classify contacts and time spent in the field for each FMO. These forms provide managers with information about:

- The number of field contacts made, which provides a context for the number of offences detected. This includes random contacts from random inspections for both sectors;
- The number of targeted⁵² contacts made, which provides information on the effectiveness of the intelligence gathering capacity at identifying 'targets';
- The number of face-to-face contacts outside of a compliance context (referred to as 'A/L/E' contacts) made, which provides information on the education effort of FMOs in a fishery; and

⁵² A targeted contact is one that is initiated because available information indicates that an offence may have been committed or may be more likely to have been committed.

- Other routine information that can be used to help managers report on where and which fisheries/sectors FMOs have undertaken patrols. This information is also used in patrol planning and risk assessments and ensures accountability of the compliance program.

A ‘compliance contact’ is contact with commercial or recreational fishers (or fishing equipment) when the legal powers of an FMO are used, whereas ‘A/L/E’ contacts’ are contacts with commercial and recreational fishers when those powers are not used.

Compliance activities in the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery are primarily focused on the peak summer period for blue swimmer crab recreational fishing in the PHE. Between December and January, all available compliance staff are directed to peak period compliance programs, which include daily 10-hour shifts of evening, night and early morning patrols, with extra staff deployed over weekends. Weekend compliance activity is rostered consistently from October until April, which is considered to be the end of the peak recreational fishing period for blue swimmer crabs in the PHE. Outside this period weekends are regularly rostered subject to adverse weather.

The number of contacts with blue swimmer crab recreational fishers in the PHE by FMOs during different time periods is shown in Figure 13.1. Note the lower contact rate in 2013/14 reflects the higher warning and infringement rate that year, resulting in FMOs spending more time processing infringements compared to making new contacts.

The DPC form also includes a section to record details of individual commercial vessel inspections / checks. These inspections may involve:

- Inspection of all fishing gear;
- Inspection of all authorizations; and
- Inspection of fish on board the boat.

The Department has also implemented an initiative called Fishwatch⁵³, whereby the community can report instances of suspected illegal fishing. The Fishwatch phone line provides a confidential quick and easy way to report any suspicious activity to Departmental compliance staff.

⁵³ <http://www.fish.wa.gov.au/About-Us/Contact-Us/Pages/Fish-watch.aspx>

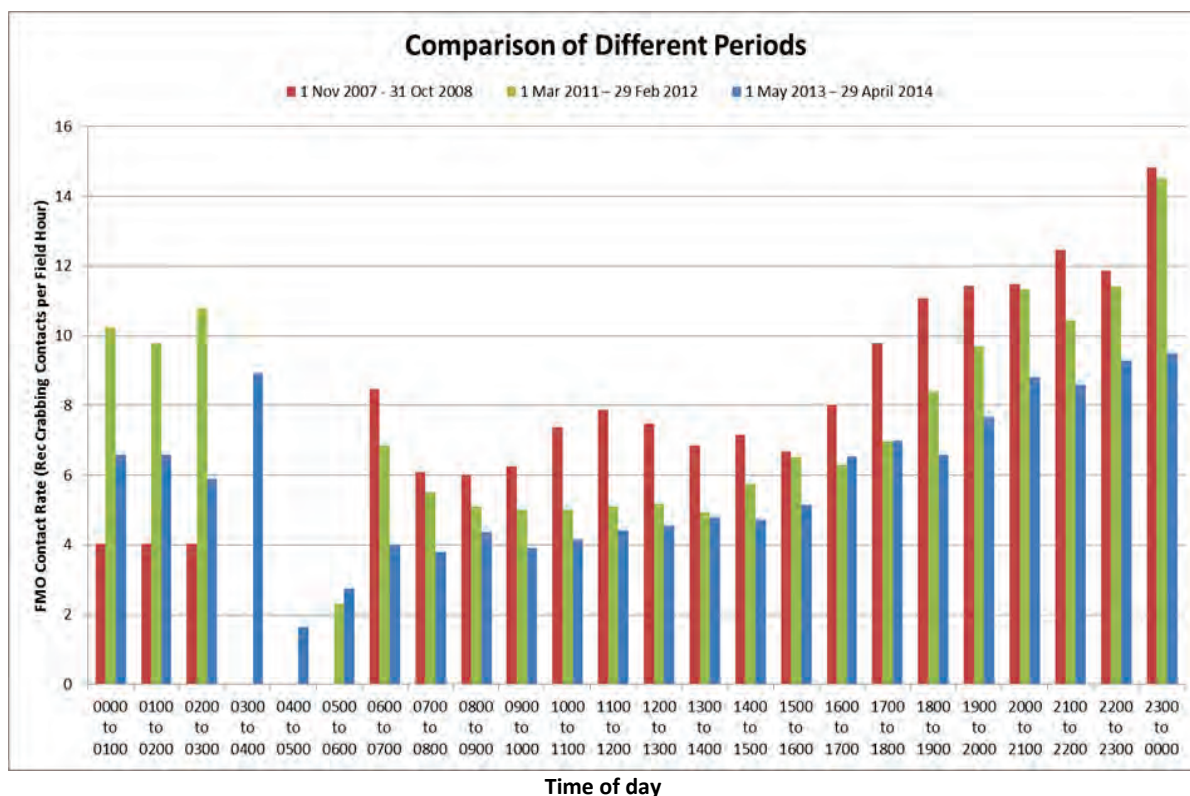


Figure 13.1. Comparison of recreational fishing compliance contact rates in the PHE at different times of the day over three different time periods.

13.4.2 Applying Sanctions

The management system in place for the WCEMF (Area 2) and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery provides a number of incentives to fish both lawfully and sustainably (see Section 12.4). These incentives, combined with explicit penalties and comprehensive MCS systems, provide a robust framework for ensuring that commercial and recreational fishers comply with the management arrangements.

There is an explicit and statutory sanction framework that is applied should a person contravene legislation relevant to the commercial and recreational fisheries in the PHE. Sanctions to deal with non-compliance in the commercial, recreational and processing sectors are listed in the FRMA and FRMR and can be severe. These sanctions consist of:

- Significant monetary penalties;
- Licence cancellations or suspensions; and
- Confiscation of gear and catch.

Sanctions applicable to the FRMA or FRMR are generally specific to each section or regulation. For example, section 74 of the FMRA sets out the sanctions applied when a clause of the West Coast Estuarine Managed Fishery Management Plan is contravened. Part 5 of the

FRMA relates to the general regulation of fishing, and recreational fishing offences are covered under this Part of the Act.

Breaches in fishery rules may occur for a variety of reasons, and FMOs undertake every opportunity to provide education, awareness and advice to fishers. However, all offences detected in the fishery are considered to be of significant concern and are addressed by FMOs via the prosecution process outlined in the Department's *Prosecution Guidelines* and rules set out in the FRMA and FRMR. When an FMO detects a breach of the FRMA, the officer determines if the matter is prosecutable (according to the Department's *Prosecution Guidelines*) and where it is, a prosecution brief is prepared by the FMO and submitted to their supervisor. Based on the *Prosecution Guidelines*, there are four tiers of enforcement measures applied by FMOs when an offence is detected in the fishery including:

- Infringement warnings: These are written warnings issued for minor offences. They do not incur a fine, but are a written record of a minor offence that may be referred to by FMOs in the future. A number of infringement warnings for similar offences in a designated period may result in an infringement notice;
- Infringement notices: These are written notifications to pay a monetary penalty for an observed offence. Fishers issued infringement notices may choose to defend the matter in court however, most fishers pay the fine. The Department may initiate a prosecution brief for habitual offenders;
- Letters of warning: A letter of warning (LOW) is a formal record of a commercial offence where a prosecution may be unduly harsh under the circumstances. A LOW may be issued where an offence has been committed but detected outside of the 45-day period where an infringement can be issued. There may not be a public interest in prosecution, but this still formally records the detected offence. A LOW formally advises the offender of their actions and seeks future 'voluntary' compliance; and
- Prosecutions: These are offences of serious nature (prescribed in the FRMA) that immediately proceed to formal, legal prosecution. Such matters often incur hefty fines or can even result in incarceration, and matters brought before the court are often vigorously defended (especially by commercial fishers).

FMOs have the autonomy to issue an infringement warning after detecting some 'minor' offences that have resulted from a lack of understanding of the rules or an error of judgment, while infringement notices are used to apply a modified penalty and are usually used in cases where the offence does not warrant prosecution action that is likely to end up in court. Modified penalties are prescribed in Schedule 12 of the FRMR and can only be applied to particular sections of the FRMA (including contravening a provision of a Management Plan) and the FRMR⁵⁴. A copy of the infringement notice is provided in Schedule 14 of the FRMR. If there is a dispute over an infringement notice, the offender can request the matter be heard in court.

⁵⁴ http://www.slp.wa.gov.au/legislation/statutes.nsf/main_mrtitle_1458_homepage.html

More serious offences against the legislation will require the Department to seek to prosecute. The Department's Prosecution Advisory Panel (PAP) reviews recommendations made by the RSD in respect to alleged offending against the FRMA (or Pearling Act) and considers whether such decisions are in the 'public interest'. This process ensures fairness, consistency and equity in the prosecution decision-making process. The PAP consists of three panel members (representing legal and executive services and the compliance and aquatic management branches) who meet on a monthly basis or as necessary. The PAP operates on a majority basis, with the prosecution process continuing where the majority of the PAP agrees with the recommendation to prosecute. If the majority of the PAP disagrees with the recommendation to prosecute, the matter is referred to the CEO of the Department, who will then make a determination on the matter. Should prosecution action be undertaken, the outcomes are generally released to the public via media releases and the Department's website⁵⁵.

Penalties for illegal activity in WA fisheries are commensurate with the value of the fish involved and the type of activity. This may result in large monetary penalties for particular activities. Large penalties are considered necessary to create a deterrent for high-value species, such as western rock lobster and abalone. General penalties are listed in section 52 of the FRMA, while additional penalty provisions that apply should there be a prosecution are provided in the FRMA under sections 222 (mandatory additional penalties based on value of fish), 223 (court ordered cancellations or suspensions of authorisations), 225 (prohibition on offender activities) and 218 (forfeiture of catch, gear, etc.).

A successful prosecution for a serious offence in a commercial fishery may result in a 'black mark' against the fisher or the commercial licence (as per section 224 of the FRMA). If an authorisation holder or a person acting on behalf of the holder accumulates three black marks within a 10-year period, the authorisation is suspended for one year. In addition, under section 143, the CEO has the administrative power to cancel, suspend or not renew an authorisation in certain circumstances, which can be used even if cancellations through the court are unsuccessful. These powers have been regularly used to deal with serious offending in other fisheries.

All fisheries offences in WA are recorded in a dedicated Departmental offences system called eBrief, which also manages the workflow associated with infringements and prosecutions. In order to link this information with patrol data, FMOs include information about the fishery, DPC area, type of patrol and whether the offence resulted from a targeted inspection in all offence paperwork.

13.4.2.1 Sanctions in the PHE

Summaries of detected offences by commercial and recreational fishers in the PHE⁵⁶ are provided in Table 13.7 and Table 13.8, respectively.

⁵⁵ See <http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/2500-fine-for-interfering-with-commercial-crab-pots.aspx> for example of media release.

⁵⁶ See <http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Officers-keeping-an-eye-on-Mandurah-crab-fishing-closure.aspx> for an example of dealing with non-compliance in the PHE.

Table 13.7. Summary of detected offences in the WCEMF Area 2 from 2010/11 to 2013/14.

Offence Type	Prosecution Briefs				Infringement Notices				Infringement Warnings			
	10/11	11/12	12/13	13/14	10/11	11/12	12/13	13/14	10/11	11/12	12/13	13/14
Failure to submit CAES returns	0	0	0	0	0	0	0	0	0	0	1	0
Obstruction	0	0	0	1	0	0	0	0	0	0	0	0
Other	0	1	1	0	0	0	0	0	0	0	0	2

Table 13.8. Summary of detected offences by recreational fishers in the PHE from 2010/11 to 2013/14.

Offence Type	Prosecution Briefs				Infringement Notices				Infringement Warnings			
	10/11	11/12	12/13	13/14	10/11	11/12	12/13	13/14	10/11	11/12	12/13	13/14
Crabbing												
Closed Season	3	0	1	0	1	11	24	10	6	6	6	5
Excess Bag & Boat Limit	22	27	13	17	20	32	18	27	6	38	41	49
Excess Gear	0	0	1	0	0	1	1	0	48	3	0	0
Illegal Gear	0	0	0	2	4	13	1	12	9	6	7	5
No RFBL	0	2	0	0	15	26	13	19	5	5	2	1
Obstruction	9	12	5	1	0	0	0	0	0	0	0	0
Spawner (species)	2	1	0	0	15	0	1	37	0	0	0	1
Undersize	32	25	12	17	111	44	72	305	208	247	260	534
Other	0	0	0	2	0	0	0	0	0	0	0	0
Netting												
Closed Season	1	1	2	2	1	0	2	2	2	0	3	1
Closed Waters	2	0	3	0	4	0	1	1	1	0	0	0
Illegal Gear	2	1	3	2	2	4	4	1	3	1	1	0
No RFBL	3	0	1	1	0	4	2	2	0	2	1	0
Undersize	2	0	1	1	1	0	0	0	10	11	3	0
Excess Bag	0	1	1	0	0	2	1	0	0	6	3	2
Species	0	0	0	0	0	1	0	0	1	0	0	0
Other	0	0	1	2	0	0	0	3	0	0	4	0

13.4.3 Level of Compliance

In evaluating compliance in a specific fishery, the Department uses a weight-of-evidence approach, which considers:

- Ongoing evidence of the fishery being sustainable, i.e. whether ecological objectives continue to be met;
- Assessment of the risk posed by the fishery to target species and ecosystem components under the current management regime;
- Annual outputs arising from formal MCS systems —
 - Adequacy of commercial compliance coverage;
 - Adequacy of recreational compliance coverage (patrol hours);
 - Number of commercial and recreational offences and successful prosecutions (dependent on whether compliance is undertaken in a random or targeted manner); and
 - Average non-targeted compliance rate;
- Number of reports of illegal activity logged by Fishwatch and from intelligence gathered by FMOs;
- Level of compliance education and communications with commercial and recreational fishers (i.e. AMMs with commercial licence holders, press releases, guides to recreational fishing rules etc.); and
- General level of community and industry support / buy-in around fishing rules.

Using this weight-of-evidence approach, commercial and recreational fishers are generally thought to comply with the management systems in place, including providing information of importance to the effective management of the fishery, based on the following:

- There is ongoing evidence that the fishery is operating sustainably, as the majority of primary performance indicators for each component (i.e. target species, retained non-target species, bycatch, ETP species, habitat and ecosystem processes) of the fisheries have been maintained above threshold reference levels (see Sections 6.1 and 9). Where indicators have fallen below the threshold (e.g. tailor and whiting), a review has been undertaken (or is currently underway) to investigate the reasons for the variation and appropriate management action will be undertaken to return the indicator above the threshold level;
- In the most recent risk assessment (see Appendix C) for the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery, the highest risk indicated to any component was ‘medium’ (i.e. the maximum acceptable level of impact). The *Status Report of the Fisheries and Aquatic Resources of Western Australia* report on the evaluation of performance of the fishery annually;
- The low level of commercial fishing offences in the WCEMF Area 2 (see Table 13.7) and the low level of prosecutions (despite high infringement rates) in the recreational fishing sector, reflecting a low re-offender rate (see below); and

- The active participation of both commercial and recreational fishers in providing extra information for the effective management of the fishery. Commercial fishers openly engage with managers and research staff when needed to provide additional information e.g. the volunteer bycatch sampling program undertaken in early 2015. Recreational fishers also regularly provide information through recreational fishing surveys and management feedback processes. For example, very high (~ 96 %) response rates of RFBL holders sampled in the 2011/12 state-wide integrated recreational fishing survey (Ryan *et al.* 2013) indicates a willingness of recreational fishers to supply information and provides confidence in overall data quality and minimises the impact of non-response bias. Results from this recreational fishing survey showed that 53 % of captured blue swimmer crabs in the WCB (including the PHE) are released (e.g. due to crab being undersize, berried females etc.), indicating widespread knowledge of, and compliance with, the recreational management system.

Despite the high number of offences in the recreational blue swimmer crab fishery in 2011 – 2014, an examination of recreational fishing offending data between 1 July 2011 and 20 June 2014 shows a very low rate repeat offenders in the recreational blue swimmer crab fishery in the PHE. Out of 1866 offenders in the fishery, only 16 were repeat offenders, which equates to < 1 %. The increase observed in recreational crabbing infringement notices and infringements warnings in the PHE in the last few years (see Table 13.8) may be as a result of a shift in compliance resources to target late night/early morning recreational fishing activities (see Figure 13.1), when recreational fishers are most active, or a result of greater fisher participation.

13.4.3.1 Community Education

A high degree of compliance effort is put into fisher education. The Department educates recreational fishers through provision of signage at boat ramps and other major access points, by publishing a range of recreational fishing rule guides⁵⁷ (published on the Department's website and available in tackleshops etc.) and producing a two-monthly "Catch" e-newsletter⁵⁸, which provides information about seasonal openings and closures, fishing rules, as well as opportunities to volunteer on education and research projects. During the peak of the recreational fishing season, the Department also issues reminder press releases to ensure recreational fishers comply with the fishing rules⁵⁹. As fishing for blue swimmer crabs is undertaken by people of a range of ethnicities and cultural backgrounds, the Departmental has developed a brochure on blue swimmer crab fishing rules in multiple languages⁶⁰. Recreational fishing rules are also provided to targeted ethnic-community based magazines (Appendix H).

The PHE is very important to the local community and an annual 'Crab Fest' is held in Mandurah to celebrate the blue swimmer crab fishery and its local importance⁶¹. Community

⁵⁷ <http://www.fish.wa.gov.au/About-Us/Publications/Recreational-Fishing/Pages/Recreational-Fishing-Guides.aspx>

⁵⁸ <http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Recreational-Fishing/Catch-E-Newsletter/Pages/default.aspx>

⁵⁹ <http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Enjoy-a-great-fishing-experience-and-stick-to-the-rules.aspx>

⁶⁰ http://www.fish.wa.gov.au/Documents/recreational_fishing/additional_fishing_information/rules_guide_crabbing_west_coast_multilingual.pdf

⁶¹ <http://www.mandurah.wa.gov.au/crabfest.htm>

pressure to do ‘the right thing’ ensures to a large extent the community police themselves. Community members regularly advise the Department, either through Fishwatch or directly to the Mandurah Regional Office, when they observe unusual or illegal behaviour. These reports are followed up by FMOs and have lead to successful prosecutions.

13.5 Research Plan

The finfish and blue swimmer crab fisheries in the PHE have a research plan in place that provides the management system with reliable and timely information sufficient to achieve the objectives consistent with MSC Principles 1 and 2. This research plan is detailed in the Department’s RMAD Plan (DoF 2012b, DoF in press). The management actions in the Department’s Fish Plan and the RMAD Plan ensure that there is a coherent and strategic approach to research in the PHE by the Department. These plans are directly responsive to the Department’s Strategic Plan⁶² and are similarly reviewed and updated regularly.

The RMAD Plan provides a mechanism to identify and track any major gaps in knowledge, resources and expertise, which assists in capacity planning, future funding applications and planning in a broader context. It is developed by scientists, managers and stakeholders who are involved across stock status (MSC Principle 1); ecology (MSC Principle 2); and governance, policy, compliance (MSC Principle 3).

The Departments’ RMAD Plan forms part of the planning cycle for determining research, monitoring and assessment needs for a fishery / asset and specifically outlines the historical, current and proposed activities that will support the collection and analysis of data to assist the Department to meet the objectives of the FRMA over a five year period (currently 2011/12-2015/16, with 2015/16-2020/21 plan in press). The plan not only documents the research, monitoring and assessment activities being done directly by the Department, but also covers any relevant activities being undertaken by other agencies that have been identified as being directly relevant to a particular fishery/sector/asset or issue. The focus of monitoring, assessment or research activities currently being undertaken within each of the fisheries / assets documented in the RMAD Plan have been the result of deliberations and discussions by internal Departmental committees and, for some sectors, with direct input from relevant industry / sector bodies (e.g. industry / advisory groups). There are four main ways that issues that require the development of further monitoring and research projects are identified (Figure 13.2):

- Monitoring that identifies issues that arise in the fishery (e.g. not achieving operational objectives; these can also be issues identified by stakeholders or researchers);
- Results of other research, management or compliance projects or investigations;
- Expert workshops (including risk assessments) and peer-reviews of aspects of research and management; and

⁶² http://www.fish.wa.gov.au/Documents/corporate_publications/strategic_plan_2009-2018_phase3.pdf

- Stakeholder (licence holders, WAFIC and Recfishwest) liaison.

Once an issue or risk specific to one, several or all aspects of a fishery has been identified, an expert group or workshop may be established to review the available information and make recommendations regarding what research should be undertaken and in many instances, help develop an appropriate research framework. For example, based on concerns about the sustainability of blue swimmer crab stocks in south-western WA following the closure of the fishery for this species in Cockburn Sound in 2006, a four-year research program for the PHE blue swimmer crab fishery was funded through the Development of Better Interests Fund (DBIF). The DBIF project involved:

- A comprehensive recreational fishery survey in the PHE between November 2007 and October 2008;
- A monthly commercial monitoring program to assess the commercial fishery in the PHE, Comet Bay and Mandurah-Bunbury blue swimmer crab fisheries; and
- Fishery-independent monitoring of blue swimmer crab stocks inside and outside the PHE (see Johnston *et al.* 2014a for more detail).

Given the diverse levels of risk and differing relative community values associated with each of the various assets, there are large differences in the level of research, monitoring and assessment activities planned among the different fisheries and ecosystems in WA. These differences also reflect the different levels of ongoing information required to enable each of the current management processes to operate effectively and generate acceptable, cost-effective outcomes.

The use of independent, peer-reviewed research or independent experts and stakeholders to identify issues and recommend and develop research projects to provide information is an important part of the research process.

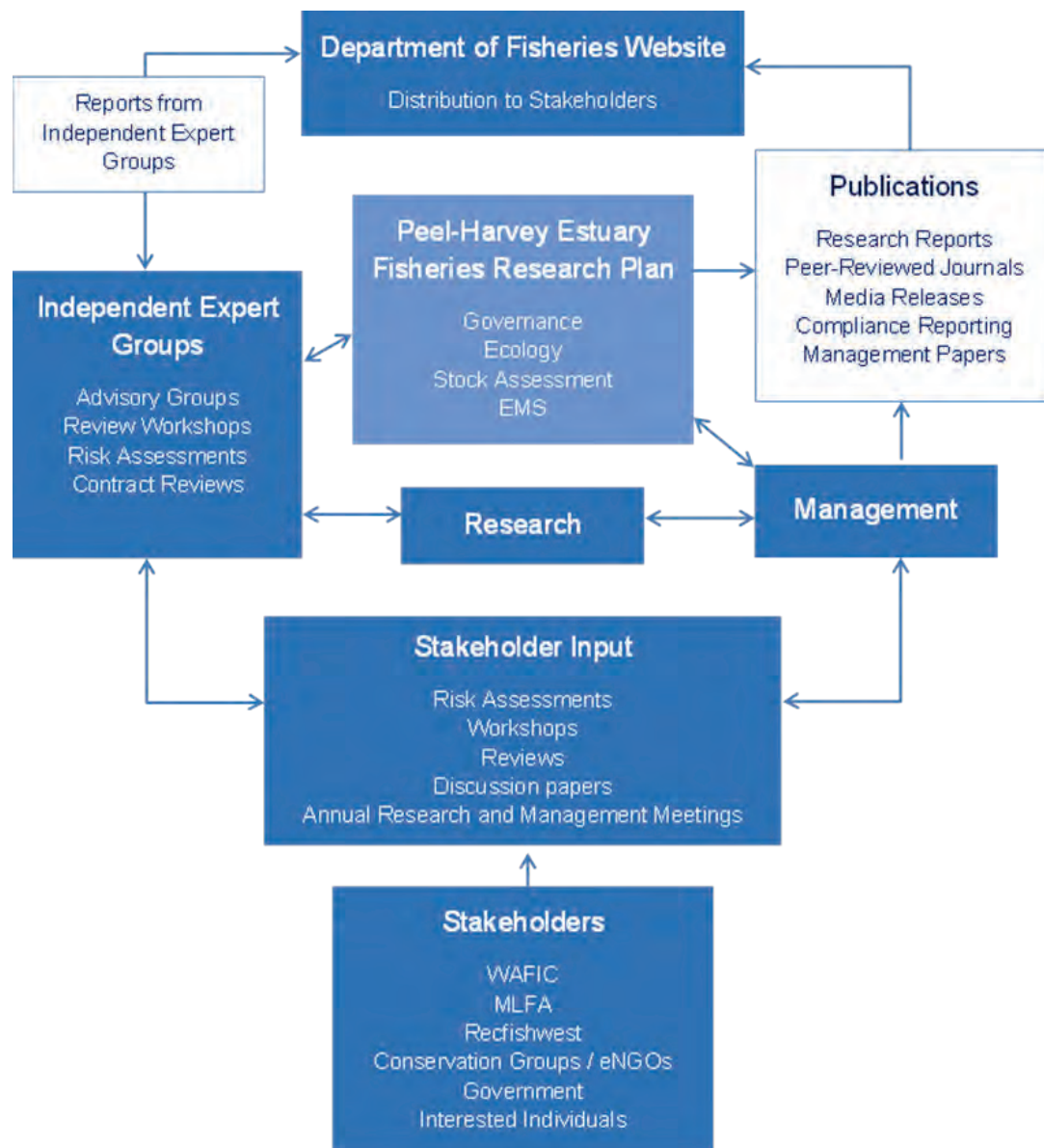


Figure 13.2. Overview of the development of the Research Plan for the PHE fishery. (Modified from figure developed by J. How for the West Coast Rock Lobster Fishery).

As outlined in the Department's 2011/12 RMAD Plan (DoF 2012b; pp. 43 – 46 for sea mullet and pp. 52 – 56 for blue swimmer crabs), ongoing research and monitoring is currently undertaken through fishers' monthly (CAES) returns data, which is used to inform annual stock assessments for these species. There are no ongoing research projects identified as part of the research plan for bycatch⁶³, ETP species and benthic habitats, as these components are considered to be a low to moderate risk. No other fishery impacts had been identified at the time of publication that warranted further research.

Broader research issues that are not necessarily PHE fisheries-specific (e.g. Fretzer 2011), particularly in the area of ecology (e.g. impact of climate change, oceanography,

⁶³ Note some bycatch monitoring occurs in the WCEMF Area 2 (blue swimmer crab fishery) as part of ongoing research monitoring activities

urban/industrial developments, etc.) are often coordinated through WAMSI, which is the umbrella organisation for all the tertiary institutions, Federal and State Government departments and corporations that have an interest in marine science in WA.

In response to compliance feedback of a gap in knowledge of blue swimmer crab recreational shore-based catch and effort in the PHE, two research projects have been outlined in the updated RMAD Plan 2015 – 2020 (DoF in press): (1) a shore-based camera survey is underway to provide 24-hour information on fishing activity of shore-based scoop netters at key locations in the estuary (see Section 8.4.2.2.1) and (2) a proposed on-site survey of shore-based recreational fishing in the PHE in order to provide blue swimmer crab catch rates from shore-based scoop netting (note this project is dependent on funding availability).

The status and progress of activities required under the research plan are closely monitored by Departmental research staff to ensure that actions are being undertaken within the designated timeframes. Any issues regarding milestones, monitoring, reporting, resourcing, etc., relevant to the plan are discussed with Departmental management staff as they arise. The Research Division's Supervising Scientists also meet fortnightly to raise any issues, which may include concerns around the timing of delivery of research programs or information. This group develops actions to address any issues and manages the peer-review process of all fisheries (with external reviewers).

The results from projects outlined in the research plan are made publicly available on the Department's website⁶⁴ in the form of FMPs, FRRs and FOPs. The outcomes of monitoring and research undertaken in accordance with the RMAD Plan are also reported in the annual *Status Report of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher & Santoro 2014), which is reviewed by the relevant Supervising Scientist, Executive Director of Research, Director of Aquatic Management and the Deputy Director General. This hierarchy of review ensures not only that each fishery is well covered but also that any impending issues (e.g. early signs of recruitment failure) are identified.

The annual review process, in combination with the periodic external reviews (e.g. the DBIF project review) and industry liaison through AMMs permit ongoing identification or re-evaluation of risks in the fishery. In turn this contributes to the identification of any additional data needs or new projects, which leads into an annual update of the Department's RMAD Plan.

For summaries of past, current and planned research and monitoring activities that support the harvest strategies for the sea mullet and blue swimmer crab resources in the PHE and other ecological components, see Sections 8.4 and 11, respectively. Examples of how research results relevant to MSC Principles 1, 2 and 3 have been used to inform management decision-making is described in Table 13.9.

⁶⁴ <http://www.fish.wa.gov.au/About-Us/Publications/Pages/default.aspx>

Table 13.9. Examples of research plan development, research undertaken, research results and how they relate to Principles 1, 2 and 3.

Fishery / Resource	Previous Data Collection	Current Research Focus/Plan	Published Research Reports	Management Actions
Peel-Harvey Estuary: sea mullet and blue swimmer crabs	<p>Details of the historical research completed and the priority setting process can be found on pp. 43 – 44 (finfish) and pp. 52 – 53 (blue swimmer crabs) of the Department of Fisheries RMAD Plan 2011/12 (DoF 2012b).</p> <p>Sea mullet were sampled between 1999 and 2002 as part of a study aimed to develop a recruitment index for several commercially and recreationally important fish species (Gaughan <i>et al.</i> 2006). For more information see Section 8.4.2.3.1.</p>	<p>Details of the current research focus can be found on pg. 44 (finfish) and pp. 53 – 54 (blue swimmer crabs) of the RMAD Plan.</p> <p>Annual meetings are held with industry to discuss research priorities and planning. The most recent formal Department and Industry meeting on research in the Peel-Harvey Estuary was held in late 2014.</p>	<p>Ryan, K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H. & Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249. Department of Fisheries, WA, 168 pp.</p>	<p>P1 & P3: Page 61 (sea mullet) established the size of the boat-based recreational fishing catch on the West Coast.</p> <ul style="list-style-type: none"> • Enables management decisions to be based on the estimated catch. <p>P1, P2 & P3: Pg. 107 (blue swimmer crabs) established the size of the recreational boat-based catch in the West Coast.</p> <ul style="list-style-type: none"> • Tested the effectiveness of recreational bag and possession limits. • Enables management decisions to be made on the estimated catch and informs resource sharing decision making. • Provides information on bycatch by boat-based drop netters.

Fishery / Resource	Previous Data Collection	Current Research Focus/Plan	Published Research Reports	Management Actions
		<p>A new project that commenced in December 2014 is aimed at monitoring shore-based recreational crabbing activity by installing cameras on the Peel-Harvey Estuary foreshore.</p> <p>Cameras will run 24-hours at four locations around the estuary. Analysis of the data will identify the patterns of crabbing activity over the full 24-hours of each day, and within different times of the year.</p>	<p>Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (2014a). 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, WA, 172 pp.</p>	<p>P1 & P3: Cht. 5 describes how the recreational fishing surveys in the Peel-Harvey Estuary in 1998/99 and 2007/08 provided information on retained and bycatch species by recreational blue swimmer crab fishers and the temporal and spatial distribution of fishing effort in the estuary.</p> <ul style="list-style-type: none"> • Information from 1998/99 survey used to inform halving of recreational bag and boat limits for blue swimmer crabs to 10 and 20 crabs, respectively, in 2007. • Commercial and recreational seasonal closures introduced in 2007. <p>P1 & P3: Will establish recreational shore-based fishing activity for blue swimmer crabs over 24-hour period and at different times of the year to inform management and compliance decision-making.</p>

Fishery / Resource	Previous Data Collection	Current Research Focus/Plan	Published Research Reports	Management Actions
Peel-Harvey Estuary Ecosystem			Hale, J. & Butcher, R. (2007). Ecological Character Description of the Peel-Yalgorup Ramsar Site. Department of Environment and Conservation and the Peel-Harvey Catchment Council, WA.	P2 & P3: Informs management of the international significance of habitat for waterbirds, and the necessity to protect them through appropriate management strategies.
			Valesini, F.J., Hourston, M., Wildsmith, M.D., Coen, N.J. and Potter, I.C. (2010) New quantitative approaches for classifying and predicting local-scale habitats in estuaries. Estuarine, Coastal and Shelf Science 86 (4): 645 – 664.	P2 & P3: Informs management of the state of the habitat and enables management decisions to be made regarding the health of the Peel-Harvey Estuary environment and fish stocks that live there.
			Fretzer, S. (2011). The Peel-Harvey Estuarine Ecosystem – system analysis and management implications. Report to the Western Australian Marine Science Institution (WAMSI) on Project 4.3.2 'Ecosystem modelling'. Murdoch University, WA. 16 pp.	P2 & P3: Informs management of the state of the habitat and enables management decisions to be made regarding the health of the Peel-Harvey Estuary environment and fish stocks that live there.

13.6 Monitoring and Management Performance Evaluation

There are mechanisms in place to monitor and evaluate the performance of the management system for the WCEMF (Area 2) and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery, which are subject to both internal and external review.

Evaluation of all parts of the management system occurs by:

(1) Departmental Strategic Planning and Risk Assessments:

- Fish Plan (internal Department high-level operational management planning document), which is reviewed annually in conjunction with WAFIC and Recfishwest;
- Internal strategic management planning meetings, which are held annually prior to AMMs to discuss issues of importance to the management of the fishery. Reviews may identify management or compliance projects or may indicate the need for major changes to the management system. Any major changes are reviewed with stakeholders and implemented through the consultation and decision-making frameworks described in Section 12.2.
- Internal strategic research planning meetings, which are held on a regular basis (at least annually). For example the blue swimmer crab DBIF project (Johnston *et al.* 2014a) arose out of this planning process.
- Internal risk assessments (that incorporate the PHE), which are undertaken every year and reported in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries*.
- Internal compliance risk assessment meetings, which are held annually. The multilingual recreational fishing brochures for the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery are an outcome of this process.
- Internal committees that convert Department and stakeholder (WAFIC and Recfishwest) priorities into operational deliverables set within the budget context.

(2) Review Workshops:

- AMMs, which are held with all WCEMF Area 2 licence holders and stakeholders (Recfishwest) to discuss current research programs, management changes and future research needs. Additional meetings may also be held, on an as needs basis, throughout the year to address specific issues or initiatives.
- Where appropriate, research workshops are also held with stakeholder groups. An example of this is the workshop held in September 2011 to review the blue swimmer crab DBIF project.

(3) Evaluation of performance against objectives:

An annual evaluation of the performance of fisheries is undertaken by Departmental research, management and compliance staff, with outcomes used to assess the extent to which the management system has met both the long- and short-term objectives of the fisheries.

Performance against the short-term (annual) objectives is measured using the performance indicators, reference levels and management control rules that are explicitly identified in harvest strategies. Where a fishery has failed to meet the short-term objective (i.e. is at or below the threshold reference level for a particular component) a review of the fishery operations, including the management system is triggered. If the review indicates that the management system is not achieving the desired objective, appropriate management action will be taken to reduce fishing impacts to an acceptable level through the mechanisms discussed in Section 13.3.

The annual fishery performance outcomes are provided to licence holders at the AMM. The Department is also required to report to Parliament on the stock assessment outcomes for all target species, with this information provided in the Department's *Annual Report*. The fishery performance outcomes for target and retained non-target species, bycatch, ETP species, habitats and ecosystems are also made publically-available in the annual *Status Report of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher & Santoro 2014).

13.6.1 Review of the Management System

Current actions across the management, assessment and monitoring, research and compliance areas for the PHE commercial and recreational fisheries for the period of 2011/12 – 2015/16 have been developed in consultation with key stakeholders and are set out in Fish Plan. However, an internal review of the management system can occur at any time should patterns emerge from annual monitoring and evaluation undertaken as part of the harvest strategy. Reviews may identify management or compliance projects or may indicate the need for major changes to the management system. Any major changes are reviewed with stakeholders and implemented through the consultation and decision-making frameworks described in Section 12.2

13.6.1.1 Management Framework

The broader management framework for fisheries in WA has been internally reviewed as part of the publication of several Departmental reports:

- *Management directions for Western Australia's estuarine and marine embayment fisheries – a strategic approach to management* (DoF 1999);
- *A Quality Future for Recreational Fishing on the West Coast* (Harrison 1999);
- *A Five-Year Management Strategy for Recreational Fishing on the West Coast of Western Australia* (Harrison 2001);

- *A Resource-Based Management Approach for Recreational Fishing In Western Australia 2012 – 2017* (DoF 2012c); and
- *Implementation of ESD for fisheries and aquaculture within WA* (DoF 2002a).

13.6.1.2 Integrated Fisheries Management / Resource Sharing

Resource sharing arrangements between commercial, recreational and customary fishing sectors have been reviewed as part of the:

- *Report to the Minister for Agriculture, Forestry and Fisheries by the Integrated Fisheries Management Review Committee* (DoF 2002b);
- *Aboriginal Fishing Strategy* (DoF 2003); and
- *Draft IFM Allocation Report for the Blue Swimmer Crab Resource in Lower West Coast of Western Australia* (IFAAC in prep.).

13.6.1.3 Risk Assessments

Internal risk assessments for the WCEMF Area 2 and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery will be undertaken periodically (every 3 – 5 years) to reassess any current or new issues that may arise in the fisheries. However, a risk assessment can also be triggered if there are significant changes identified in fishery operations or management activities or controls. Each new risk assessment will inform a major review of the management system, including Fish Plan, the RMAD (Research) Plan and compliance requirements (i.e. compliance risk assessments and OCPs). This review also takes into account the level of resourcing across the management, research and compliance divisions for the fisheries, which can be modified if the level of risk indicates a change is required.

13.6.1.4 Management Strategies

The harvest strategies developed for the finfish and blue swimmer crab resources of the PHE were subject to extensive internal review (with the Department's management and research Divisions) and stakeholder consultation in 2014 and 2015, as part of the preparation for MSC full assessment. While the next review of these harvest strategies will occur in 2020, the documents may be subject to further review and amended as appropriate within the five year period as relevant information becomes available (e.g. new research, risk assessments, expert advice etc.).

13.6.1.5 Other Reviews

The research and management of the PHE blue swimmer crab fishery was externally reviewed in 2010 by Dr Wayne Sumpton (Department of Agriculture and Fisheries, Queensland) as part of the DBIF project (Johnston *et al.* 2014; see Appendix C).

14. References

Note that a list additional materials and published references provided to the Certification Assessment Body as part of the assessment of this fishery against the MSC standard, that are not listed below, are provided in Appendix I.

14.1 General References (Sections 1 – 5)

- Aguilar, R., Hines, A.H., Wolcott, T.G., Wolcott, D.L., Krawer, M.A. & Lipcius, R.N. (2005). The timing and route of movement and migration of post-copulatory female blue crabs, *Callinectes sapidus* Rathbun, from the upper Chesapeake Bay. *Journal of Experimental Marine Biology and Ecology* 319: 117-128.
- Bellchambers, L., Sumner, N. & Melville-Smith, R. (2005). Development of stock allocation and assessment techniques in Western Australia blue swimmer crab fisheries. Report to the FRDCon Project No. 2001/068. Department of Fisheries, WA, 205 pp.
- Bradby, K. (1997). Peel-Harvey: the decline and rescue of an ecosystem. Greening the Catchment Taskforce (Inc.), Mandurah, WA, 223 pp.
- Burke, J. & Rodgers, L. (1981). Identification of pathogenic bacteria associated with the occurrence of 'red spot' in sea mullet, *Mugil cephalus* L. in south-eastern Queensland. *Journal of Fish Diseases* 4: 153-159.
- Chaplin, J.A. & Sezmiş, 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. Report prepared for the Department of Fisheries, WA. Murdoch University, WA.
- Chaplin, J.A., Yap, E.S., Sezmiş, E. & Potter, I.C. (2001). Genetic (microsatellite) determination of the stock structure of the blue swimmer crab in Australia. Report to the FRDC on Project No. 98/118. Murdoch University, WA, 84 pp.
- Chubb, C.F., Potter, I.C., Grant, C.J., Lenanton, R.C.J. & Wallace, J.H. (1981). Age structure, growth rates and movements of sea mullet, *Mugil cephalus* L., and yellow eye mullet, *Aldrichetta forsteri* (Valenciennes), in the Swan-Avon River System, Western Australia. *Australian Journal of Marine and Freshwater Research* 32: 605-628.
- City of Mandurah. (2014). Channel Seven Mandurah Crab Fest. Last accessed 6 June 2014 from: <http://www.mandurah.wa.gov.au/crabfest.htm>.
- Crisafulli, B. (2008). Biology of two fish species of mullet (Mugilidae) in five estuaries on the south coast of Western Australia. Honours thesis. Murdoch University, WA, 121 pp.
- Davies, J. (1964). A morphogenic approach to world shorelines. *Zeitschrift für Geomorphologie* 8: 127-142.
- de Lestang, S., Platell, M.E. & Potter, I.C. (2000). Dietary composition of the blue swimmer crab *Portunus pelagicus* L. Does it vary with body size and shell state and between estuaries? *Journal of Experimental Marine Biology and Ecology* 246: 241-257.
- de Lestang, S., Hall, N.G. & Potter, I.C. (2003a). Reproductive biology of the blue swimmer crab, *Portunus pelagicus* (Decapoda: Portunidae) in five water bodies on the west coast of Australia. *Fishery Bulletin* 101: 745-757.

- de Lestang, S., Hall, N. & Potter, I.C. (2003b). Changes in density, age composition and growth rate of *Portunus pelagicus* in a large embayment in which fishing pressures and environmental conditions have been altered. *Journal of Crustacean Biology* 23(4): 908-919.
- de Lestang, S., Hall, N.G. & Potter, I.C. (2003c). Do the age compositions and growth of the crab *Portunus pelagicus* in marine embayments and estuaries differ? *Journal of the Marine Biological Association of the United Kingdom* 83: 971-978.
- 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. and Woodby D. (eds.), *Biology and Management of Exploited Crab Populations under Climate Change*. Alaska Sea Grant, University of Alaska Fairbanks.
- Department of Conservation and Environment. (1985). Peel-Harvey Estuarine System Study. Report on Mandurah Attitudinal Survey. Bulletin 235. Department of Conservation and Environment, Perth, WA, 72 pp.
- Department of Water. (1998). Dawesville Channel Monitoring Programme Technical Review Summary. Department of Water, WA.
- Department of Fisheries (DoF) (2014a). Recreational Fishing Guide 2014. Department of Fisheries, WA.
http://www.fish.wa.gov.au/Documents/recreational_fishing/rec_fishing_guide/rules_guide_statewide.pdf
- DoF. (2014b). Recreational Net Fishing Guide 2014/5. Department of Fisheries, WA.
http://www.fish.wa.gov.au/Documents/recreational_fishing/licences/rec_licence_netting.pdf
- Edgar, G.J. (1990). Predator-prey interactions in seagrass beds. II. Distribution and diet of the blue manna crab *Portunus pelagicus* Linnaeus at Cliff Head, Western Australia. *Journal of Experimental Marine Biology and Ecology* 139: 23-32.
- Environmental Protection Authority (EPA). (2011). Report and recommendations of the Environmental Protection Authority: Point Grey Marina. Point Grey Development Company Pty Ltd., 77 pp.
<http://edit.epa.wa.gov.au/EPADocLib/Rep%201420%20Point%20Grey%20Marina%20PER%20051211.pdf>
- Fisher, M.R. (1999). Effect of temperature and salinity on size at maturity of female blue crabs. *Transactions of the American Fisheries Society* 128: 499-506.
- Fletcher, W. & Santoro, K. (eds). (2014). Status reports of the fisheries and aquatic resources of Western Australia 2013/14: State of the Fisheries. Department of Fisheries, WA.
- FRDC. (2012). Nets. http://www.fish.gov.au/fishing_methods/Pages/nets.aspx. Last accessed June 6, 2014.
- Fraser, A.J. (1953). The river or sea mullet of Western Australia. Monthly Service Bulletin (WA Fisheries Department) 2: 183-196.
- Fretzer, S. (2011). The Peel-Harvey Estuarine Ecosystem – system analysis and management implications. Report to the Western Australian Marine Science Institution (WAMSI) on Project 4.3.2 ‘Ecosystem modelling’. Murdoch University, WA. 16 pp.

- Gaughan, D.J., Ayvazian, S., Nowara, G., Craine, M. & Brown, J. (2006). The development of a rigorous sampling program for a long term annual index of recruitment for finfish species from south-western Australia. Report to the FRDC on Project No. 1999/153, Fisheries Research Report No. 154. Department of Fisheries, WA, 135 pp.
- Gentilli, J. (1971). Climate of Australia and New Zealand. World Survey of Climatology, Vol. 13. Elsevier Publishing Company, Amsterdam.
- Grant, C. & Spain, A. (1975). Reproduction, growth and size allometry of *Valamugil seheli* (Forsk.) (Pisces: Mugilidae) from north Queensland inshore waters. *Australian Journal of Zoology* 23: 463-474.
- Hale, J. (2008). Monitoring and Evaluation Guide for the Peel-Yalgorup Ramsar Site, A report to the Peel-Harvey Catchment Council and the Department of Environment and Conservation. http://www.mandurah.wa.gov.au/HBIItem_114395.PDF
- Hale, J. & Butcher, R. (2007). Ecological Character Description of the Peel-Yalgorup Ramsar Site. Department of Environment and Conservation and the Peel-Harvey Catchment Council, Perth, WA.
- Harrison, J.J. & Senou, H. (1999). Order Mugiliformes. In: K.E. Carpenter, V.H. Niem (eds.), The living marine resources of the Western Central Pacific. FAO Species Identification Guide for Fisheries Purposes. FAO, Rome, Italy, pp. 2069-2790.
- Hodgkin, E., Birch, P., Black, R. & Humphries, R. (1981). The Peel-Harvey Estuarine System Study 1976-1980. Department of Conservation and Environment Report No. 9. Department of Conservation and Environment, Perth, WA.
- Hoenig, J. (1983). Empirical use of longevity data to estimate mortality rates. *Fishery Bulletin* 82: 898-903.
- Hotbite. (2012). How to catch blue manna crabs. Last accessed 6 June 2014 from: http://www.hotbite.com.au/content/fishing_articles_wa/?artid=21&thePage=3.
- Hutchins, B. & Swainston, R. (1999). Sea fishes of southern Australia, 2nd edition. Swainston Publishing, New South Wales, Australia, 180 pp.
- Integrated Fisheries Allocation Advisory Committee (IFAAC). (in prep.). Draft Allocation Report: Lower West Coast Crab Resource. Department of Fisheries, WA, 56 pp.
- Johnston, D., Harris, D., Caputi, N. & Thomson, A. (2011a). 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. <http://www.sciencedirect.com/science/article/pii/S0165783611000476#>
- Johnston, D., Harris, D., Caputi, N., de Lestang, S. & Thomson, A. (2011b). Status of the Cockburn Sound Crab Fishery. Fisheries Research Report No. 219. Department of Fisheries, WA, 104 pp. http://www.fish.wa.gov.au/Documents/research_reports/frr219.pdf
- Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (2014a). 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, WA, 172 pp.
- Josileen, J. (2011). Morphometrics and length-weight relationship in the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758) (Decapoda, Brachyura) from the Mandapam Coast, India. *Crustaceana* 84: 1665-1681.

- Kailola, P.J., Williams, M.J., Stewart, P.C., Reichelt, R.E., McNee, A. & Grieve, C. (1993). Australian Fisheries Resources. Bureau of Resource Sciences, Department of Primary Industries and Energy, and the FRDC, Canberra, Australia.
- Kangas, M.I. (2000). Synopsis of the biology and exploitation of the blue swimmer crab, *Portunus pelagicus* Linnaeus, in Western Australia. Report No. 121. Department of Fisheries, WA, 22 pp.
- Lai, E., Hall, N., Telfer, C., Eyres, J. & Wise, B. (2014). Recreational surveys of catch and effort for blue swimmer crabs in the Peel-Harvey Estuary. In: Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (eds.), 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., pp. 70-105. Department of Fisheries, WA.
- Lai, J., Ng, P.K.L. & Davie, P.J.F. (2010). A revision of the *Portunus pelagicus* species complex (Crustacea: Brachyura: Portunidae) with the recognition of four species. *Raffles Bulletin of Zoology* 58(2): 199-237.
- Leis, J.M. & Carson-Ewart, B.M. (2000). The larvae of Indo-Pacific coastal fishes: a guide to identification (Fauna Malesiana Handbook 2). Brill: Leiden.
- Lenanton, R.C.J. (1978). Fish and exploited crustaceans of the Swan-Canning estuary. Department of Fisheries and Wildlife Report No. 35. Department of Fisheries and Wildlife, WA, 36 pp.
- Lenanton, R.C.J. (1984). The Commercial Fisheries of Temperate Western Australian Estuaries: Early Settlement to 1975. Report No. 62. Department of Fisheries and Wildlife, WA, 82 pp.
- Liao, I.C. (1974). The experiments on the induced breeding of grey mullet in Taiwan from 1963 to 1973. *Aquaculture* 6: 31-58.
- Malseed, B.E. & Sumner, N.R. (2001). 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, WA, 52 pp.
- Meagher, T.D. (1971). Ecology of the crab *Portunus pelagicus* (Crustacea Portunidae) in south-western Australia. PhD thesis. University of WA. 232 pp.
- MLFA. (2008). Environmental Management System: A voluntary, industry-driven, environmental initiative. OceanWatch; WAFIC; SeaNet.
- Orr, P. (2000). The biology of four commercial fish species in a seasonally closed estuary. PhD thesis. Murdoch University, WA, 275 pp.
- Paperna, I. & Overstreet, R.M. (1981). Parasites and diseases of mullets (Mugilidae). In: Oren, O.H. (ed.), Aquaculture of Grey Mullet, Chapter 13. International Biological Programme 26. Cambridge University Press.
- Penn, J.W. (1977). Trawl caught fish and crustaceans from Cockburn Sound. Report No. 20. Department of Fisheries and Wildlife, WA.
- Peel-Harvey Catchment Council (PHCC). (2009). Peel-Yalgorup Ramsar Site Management Plan. Peel-Harvey Catchment Council, Mandurah, WA, 193 pp.
http://www.mandurah.wa.gov.au/HBIItem_114403.PDF

- Potter, I.C. & de Lestang, S. (2000). The biology of the blue swimmer crab *Portunus pelagicus* in the Leschenault Estuary and Koombana Bay in south-western Australia. *Journal of the Royal Society of Western Australia* 83: 443-458.
- Potter, I.C., Chrystal, P.J. & Loneragan, N.R. (1983). The biology of the blue manna crab *Portunus pelagicus* in an Australian estuary. *Marine Biology* 78: 75-85.
- Potter, I.C., de Lestang, S. & Young, G.C. (1998). Influence of the Dawesville Channel on the recruitment, distribution and emigration of crustaceans and fish in the Peel-Harvey Estuary. Report to the FRDC on Project No. 95/042. 61 pp.
- Potter, I.C., Chalmer, P.N., Tiivel, P.N., Steckis, R.A., Platell, M.E. & Lenanton, R. (2000). The fish fauna and finfish fishery of the Leschenault Estuary in south-western Australia. *Journal of the Royal Society of Western Australia* 83: 481-501.
- Potter, I.C., de Lestang, S. & Melville-Smith, R. (2001). The collection of biological data required for management of the blue swimmer crab fishery in the central and lower west coasts of Australia. Report to the FRDC on Project No. 97/137. Canberra, Australia. 54 pp. + appendices.
- Rossi, A.R., Capula, M., Crosetti, D., Campton, D.E. & Sola, L. (1998). Genetic divergence and phylogenetic inferences in five species of Mugilidae (Pisces: Perciformes). *Marine Biology* 131: 213-218.
- Ryan, K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H. & Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249. Department of Fisheries, WA, 168 pp.
- Ryan, K.L., *et al.* (in prep.). An integrated system to survey boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. xxx. Department of Fisheries, WA.
- Sezmiş, E. (2004). The population genetic structure of *Portunus pelagicus* in Australian waters. PhD thesis, Murdoch University, WA.
- Smith, H. (1982). Blue crabs in South Australia – their status, potential and biology. *South Australian Fishing Industry Council* 6: 33-51.
- Smith, K. (2006). Review of fishery resources and status of key fishery stocks in the Swan-Canning Estuary. Fisheries Research Report No. 156. Department of Fisheries, WA, 84 pp.
- Smith, K.A. & Deguara, K. (2002). Review of biological information and stock assessment for the NSW sea mullet resource. New South Wales Fisheries Resource Assessment Series No. 12. New South Wales Fisheries, Cronulla, Australia, 23 pp.
- Smith G.S. & Sumpton, W.D. (1987). Sand crabs a valuable fishery in southeast Queensland. *Queensland Fisherman* 5: 13-15.
- Smith, K., Quinn, A., Holtz, M. & Nardi, K. (2014). West Coast Nearshore and Estuarine Finfish Resources Status Report. In W. Fletcher & K. Santoro (eds.), Status Reports of the Fisheries and Aquatic Resources of Western Australia 2013/14: the state of the fisheries (pp. 67-82). Department of Fisheries, WA.
- Sumpton, W.D., Smith, G.S. & Potter, M.A. (1989). Notes on the biology of the portunid crab, *Portunus sanguinolentus* (Herbst), in subtropical Queensland waters. *Australian Journal of Freshwater Research* 40: 711-717.

- Thomson, J.M. (1963). Synopsis of biological data on the grey mullet *Mugil cephalus* Linnaeus 1758. Fishery Synopsis No. 1. Division of Fisheries and Oceanography, CSIRO, 66 pp.
- Valesini, F., Hourston, M., Wildsmith, M., Coen, N., & Potter, I. (2010). New quantitative approaches for classifying and predicting local-scale habitats in estuaries. *Estuarine, Coastal and Shelf Science* 86: 645-664.
- Virgona, J., Deguara, K., Sullings, D., Halliday, I. & Kelly, K. (1998). Assessment of the stocks of sea mullet in New South Wales and Queensland waters. Report to the FRDC on Project No. 94/024. New South Wales Fisheries Research Institute. Cronulla, New South Wales. Australia, 133 pp.
- Williams, M.J. (1982). Natural food and feeding in the commercial sand crab *Portunus pelagicus* Linnaeus, 1766 (Crustacea: Decapoda: Portunidae) in Moreton Bay, Queensland. *Journal of Experimental Marine Biology and Ecology* 59: 165-176.

14.2 MSC Principle 1 References (Sections 6 – 8)

- Biseau, A. (1998). Definition of a directed fishing effort in a mixed-species trawl fishery, and its impact on stock assessments. *Aquatic Living Resources* 11(3): 119-136.
- Craine, M. (2005). Modelling Western Australian fisheries with techniques of time series analysis: examining data from a different perspective. Report to the FRDC on Project No. 1999/155. Department of Fisheries, WA, 158 pp.
- de Lestang, S. (2002). Biology of the blue swimmer crab, *Portunus pelagicus* (Linnaeus), in Western Australia. PhD thesis. Murdoch University, WA, 173 pp.
- de Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A. & Stephenson, P. (2012). Stock Assessment for the West Coast Rock Lobster Fishery. Fisheries Research Report No. 217. Department of Fisheries, WA, 200 pp.
- DoF (2008). West Coast Rock Lobster Managed Fishery: Recommended management changes for the 2008/09 season. Department of Fisheries, WA http://www.fish.wa.gov.au/Documents/occasional_publications/fop049.pdf
- DoF (2011). Resource Assessment Framework (RAF) for finfish resources in Western Australia. Fisheries Occasional Publication No. 85. Department of Fisheries, Perth, WA, 28 pp.
- DoF (2013). West Coast Rock Lobster Harvest Strategy and Control Rules 2015 – 2019. A Discussion Paper. Fisheries Management Paper No. 263. Department of Fisheries, WA.
- DoF. (2015a). Finfish Resources of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020. Fisheries Management Paper No. 274. Department of Fisheries, WA.
- DoF. (2015b). Blue Swimmer Crab Resource of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020. Fisheries Management Paper No. 273. Department of Fisheries, WA.
- DoF. (2015c). Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia. Fisheries Management Paper No. 271. Department of Fisheries, WA.
- ESD Steering Committee (1992). National Strategy for Ecologically Sustainable Development. Endorsed by the Council of Australian Governments, December 1992. ISBN 0 644 27253 8.

- Fletcher, W. & Santoro, K. (eds). (2014). Status reports of the fisheries and aquatic resources of Western Australia 2013/14: State of the Fisheries. Department of Fisheries, WA.
- Freeman, S.N. & Kirkwood, G.P. (1995). On a structural time series method for estimating stock biomass and recruitment from catch and effort data. *Fisheries Research* 22: 77-98.
- Gaughan, D.J., Ayvazian, S., Nowara, G., Craine, M. & Brown, J. (2006). The development of a rigorous sampling program for a long term annual index of recruitment for finfish species from south-western Australia. Report to the FRDC on Project No. 1999/153, Fisheries Research Report No. 154. Department of Fisheries, WA, 135 pp.
- Johnston, D., Harris, D., Caputi, N. & Thomson, A. (2011a). 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.
<http://www.sciencedirect.com/science/article/pii/S0165783611000476#>
- Johnston, D., Harris, D., Caputi, N., de Lestang, S. & Thomson, A. (2011b). Status of the Cockburn Sound Crab Fishery. Fisheries Research Report No. 219. Department of Fisheries, WA, 104 pp.
http://www.fish.wa.gov.au/Documents/research_reports/frr219.pdf
- Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (2014a). 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, WA, 172 pp.
- Lai, E., Hall, N., Telfer, C., Eyres, J. & Wise, B. (2014). Recreational surveys of catch and effort for blue swimmer crabs in the Peel-Harvey Estuary. In: Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (eds.), 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, pp. 70-105. Department of Fisheries, WA.
- Malseed, B.E. & Sumner, N.R. (2001). 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, WA, 52 pp.
- Marriott, R.J., O'Neill, M.F., Newman, S.J., & Skepper, C.L. (2014). Abundance indices for long-lived tropical snappers: estimating standardized catch rates from spatially and temporally coarse logbook data. *ICES Journal of Marine Science* 71(3): 618–627.
- Melville-Smith, R., Bellchambers, L. M. and Kangas, M. (2001). The collection of fisheries data for the management of the blue swimmer crab fishery in central and lower coasts of Australia. Report to the FRDC on Project No. 98/121. Department of Fisheries, WA, 103 pp.
- Mendelssohn, R. (1981). Using Box-Jenkins models to forecast fishery dynamics: identification, estimation, and checking. *Fishery Bulletin* 78: 887-896.
- MSC. (2013). Guidance to the MSC Certification Requirements. Version 1.3, 14 January 2013, 254 pp.
- Noakes, D.J., Welch, D.W., Henderson, M. & Mansfield, E. (1990). A comparison of preseason forecasting methods for returns of two British Columbia sockeye salmon stocks. *North American Journal of Fisheries Management* 10: 46-57.

- Potter, I.C., Chrystal, P.J. & Loneragan, N.R. (1983). The biology of the blue manna crab *Portunus pelagicus* in an Australian estuary. *Marine Biology* 78: 75-85.
- Ryan, K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H. & Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249. Department of Fisheries, WA, 168 pp.
- Ryan, K.L., *et al.* (in prep.). An integrated system to survey boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. xxx. Department of Fisheries, Western Australia.
- Saila, S.B., Wigbout, M. & Lermitt, R.J. (1980). Comparison of some time series models for the analysis of fisheries data. *Journal du Conseil Permanent International Pour L'Exploration de la Mer* 39: 44-52.
- Scientific Certification Systems. (2008). Final MSC Assessment Report. The Lakes and Coorong Fisheries, Southern Australia. Scientific Certification Systems, Inc. Emeryville, California, United States, 184 pp.
- Sloan, S.R., Smith, A.D.M., Gardner, C., Crosthwaite, K., Triantafillos, L., Jeffries, B. and Kimber, N. (2014). National Guidelines to Develop Fishery Harvest Strategies. FRDC Report – Project 2010/061. Primary Industries and Regions, South Australia, Adelaide.
- 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. Fisheries Research Report No. 246. Department of Fisheries, WA, 200 pp.
- Stergiou, K.I., Christou, E.D. & Petrakis, G. (1997). Modelling and forecasting monthly fisheries catches: comparison of regression, univariate and multivariate time series methods. *Fisheries Research* 29: 55-95.
- Sumner, N.R., Williamson, P.C., Blight, S. & Gaughan, D.J. (2008). A 12-month survey of recreational boat-based fishing between Augusta and Kalbarri on the west coast of Western Australia 2005–06. Fisheries Research Report No. 177. Department of Fisheries, WA, 44 pp.
- Wise, B.S. & Fletcher, W.J. (2013). Determination and development of cost effective techniques to monitor recreational catch and effort in Western Australian demersal finfish fisheries. Final Report for FRDC Project 2005/034 and WAMSI Subproject 4.4.3. Fisheries Research Report No. 245. Department of Fisheries, WA, 168pp.
- Wise, B.S., St. John, J. & Lenanton, R. (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. Report to the FRDC on Project No. 2003/052. Fisheries Research Report No 163. Department of Fisheries, WA, 130 pp.

14.3 MSC Principle 2 References (Sections 9 – 11)

- Ayvazian, S.G., Bastow, T.P., Edmonds, J.S., How, J. & Nowara, G. (2004). Stock structure of Australian herring (*Arripis georgiana*) in southwestern Australia. *Fisheries Research* 67: 39-53.
- DAL. (2002). Dawesville Channel Monitoring Programme: Five Year Technical Review. Perth: Water and Rivers Commission.

- DoF. (2011). Resource Assessment Framework (RAF) for Finfish Resources in Western Australia. Fisheries Occasional Publication No. 85. Department of Fisheries, WA.
- Department of Fisheries (DoF). (2015a). Finfish Resources of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020. Fisheries Management Paper No. 274. Department of Fisheries, Western Australia.
- Edgar, G.J. (1997). Australian Marine Life: the plants and animals of temperate waters. Reed Books, Melbourne, 544 pp.
- Eno, N.C.; MacDonald, D.S.; Kinnear, J.A.M.; Amos, C.S.; Chapman, C.J.; Clark, R.A.; Bunker, F. St P.D. and Munro, C. (2001). Effects of crustacean traps on benthic fauna. *ICES Journal of Marine Science* 58: 11 – 20.
- Hale, J. & Butcher, R. (2007). Ecological Character Description of the Peel-Yalgorup Ramsar Site. Department of Environment and Conservation and the Peel-Harvey Catchment Council, WA.
- Hodgkin, E., Birch, P., Black, R. & Humphries, R. (1981). The Peel-Harvey Estuarine System Study 1976-1980. Perth: Department of Conservation and Environment Report No. 9.
- Humphries, R.B. & Croft, C.M. (1984). Management of the Eutrophication of the Peel-Harvey Estuarine System. Final Report - Bulletin 165. Department of Conservation and Environment, WA.
- Humphries, R. & Robinson, S. (1995). Assessment of the Success of the Peel-Harvey Estuary System Management Strategy - A Western Australian Attempt at Integrated Catchment Management. *Water Science & Technology* 32 (5-6): 255-264.
- Johnston, D., Evans, R., Foster, M., Blay, N. & Rome, B. (2014b). West Coast Blue Swimmer Crab Fishery Status Report. In: W. Fletcher, and K. Santoro (eds.), Status Reports of the Fisheries and Aquatic Resources of Western Australia 2013/14: the State of the Fisheries, pp. 57-66. Department of Fisheries, WA.
- Joll, L.M. (1976). Mating, egg-laying and hatching of *Octopus tetricus* (Mollusca: Cephalopoda) in the laboratory. *Marine Biology* 36: 327-333.
- Lai, E., Hall, N., Telfer, C., Eyres, J. & Wise, B. (2014). Recreational surveys of catch and effort for blue swimmer crabs in the Peel-Harvey Estuary. In: Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (eds.), 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., pp. 70-105. Department of Fisheries, WA.
- Loneragan, N., Potter, I., Lenanton, R. & Caputi, N. (1986). Spatial and seasonal differences in the fish fauna in the shallows of a large Australian estuary. *Marine Biology* 92: 575-586.
- Malseed, B.E. & Sumner, N.R. (2001) 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, WA, 48 pp.
- McComb, A.J. & Lukatelich, R.J. (1995). The Peel-Harvey Estuarine System, Western Australia. In: McComb, A.J. (ed.), Eutrophic Shallow Estuaries and Lagoons. Perth, CRC Press, Inc.

- MLFA. (no date). Environmental Management System: A voluntary, industry-driven, environmental initiative. OceanWatch; WAFIC; SeaNet.
- Moore, G.I. & Chaplin, J.A. (2013). Population genetic structures of three congeneric species of coastal pelagic fishes (*Arripis*: Arripidae) with extensive larval, post-settlement and adult movements. *Environmental Biology of Fishes* 96: 1087-1099.
- MSC. (2013). Guidance to the MSC Certification Requirements. Version 1.3, 14 January 2013, 254 pp.
- National Heritage Trust. (2005). Protected Marine Species Identification Guide. Canberra: Department of Environment and Heritage.
- National Trust of Australia. (1973). The Peel-Preston Lakelands. National Trust of Australia, WA.
- Pedretti, Y.M., Kobryn, H.T., Sommerville, E.F. & Wienczugow, K. (2011). Snapshot survey of the distribution and abundance of seagrass and macroalgae in the Peel-Harvey Estuary from November/December 2009. Report to the Department of Water. Marine and Freshwater Research Laboratory Environmental Science, Murdoch University, WA, 89 pp.
- Peel Inlet Management Authority (1994). Dawesville Channel: Environmental Impacts and Their Management Perth: Working Paper - Report 50, Waterways Commission.
- Potter, I., & Hyndes, G. (1999). Characteristics of the ichthyofaunas of southwestern Australian estuaries, including comparisons within holarctic estuaries and estuaries elsewhere in Australia: a review. *Australian Journal of Ecology* 24: 395-421.
- Ryan, K., Wise, B., Hall, N., Pollock, K., Sulin, E. & Gaughan, D. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Department of Fisheries, WA.
- Ryan, K.L., *et al.* (in prep.). An integrated system to survey boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. xxx. Department of Fisheries, WA.
- Shester, G.G. & Micheli, F. (2011). Conservation challenges for small-scale fisheries: bycatch and habitat impacts of traps and gillnets. *Biological Conservation* 144: 1673 – 1681.
- Smallwood, C.B., Hesp, S.A. & Beckley, L.E. (2013). Biology, stock status and management summaries for selected fish species in south-western Australia. Fisheries Research Report No. 242. Department of Fisheries, WA, 180 pp.
- Smith, K. & Brown, J. (2014). Biological synopsis of Australian herring (*Arripis georgianus*). Fisheries Research Report No. 251. Department of Fisheries, WA, 40 pp.
- 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. Fisheries Research Report No. 246. Department of Fisheries, WA, 200pp.
- Smith, K., Quinn, A., Holtz, M. & Nardi, K. (2014). West Coast Nearshore and Estuarine Finfish Resources Status Report. In W. Fletcher & K. Santoro (eds.), Status Reports of the Fisheries and Aquatic Resources of Western Australia 2013/14: the state of the fisheries (pp. 67-82). Department of Fisheries, WA.

- Valesini, F., Coen, N., Wildsmith, M., Hourston, M., Tweedly, J., Hallett, C., . . . & Potter, I. (2009). Relationships between fish faunas and habitat type in south-western Australian estuaries. FRDC Final Report Project 2004/045. Murdoch University, WA.
- Valesini, F.J., Hourston, M., Wildsmith, M.D., Coen, N.J. and Potter, I.C. (2010) New quantitative approaches for classifying and predicting local-scale habitats in estuaries. *Estuarine, Coastal and Shelf Science* 86 (4): 645 – 664.
- Wadley, V.A. & Dunning, M. (1998). Cephalopods of importance in Australian fisheries. CSIRO, Hobart.
- Water and Rivers Commission. (2004). Condition statement for the Peel-Harvey Estuarine System, Western Australia-as at April 2004. Water and Rivers Commission.
- Wilson, B.R. (1994). A representative marine reserve system for Western Australia. Report of the Marine Parks and Reserves Selection Working Group. Published by the Department of Conservation and Land Management, Perth.
- Wilson, C., Latchford, J. & Paling, E. (1997). Macrophyte Abundance and Composition in the Peel-Harvey Estuary from July 1996 to June 1997, with Biomass Comparisons Before and After the Dawesville Channel. Perth: Report to the Waterways Commission, Perth, Western Australia. Marine and Freshwater Research Laboratory, Report No. MAFRL 97/5.
- Wilson, C., Hale, J. & Paling, E. (1999). Macrophyte abundance and composition in the Peel-Harvey Estuary: comparisons before and after the opening of the Dawesville Channel (July 1985 to June 1999). Institute for Environmental Science, Report No. MAFRL 99/5.
- Young, G. (2000). The fish fauna of two south-western Australian estuaries: influence of an artificial entrance channel and of hypersalinity and prolonged closure. PhD Thesis. Murdoch University, WA.
- Young, G. & Potter, I. (2003). Do the characteristics of the ichthyoplankton in an artificial and natural entrance channel of a large estuary differ? *Estuarine, Coastal and Shelf Science* 56: 765-779.

14.4 MSC Principle 3 References (Sections 12 – 13)

- Brayford, H.G. & Lyon, G.E. (1995). Offshore Constitutional Settlement 1995. Fisheries Management Paper No. 77. Department of Fisheries, WA. Accessed 9 February 2015 from: http://www.fish.wa.gov.au/Documents/management_papers/fmp077.pdf
- Commonwealth of Australia (CoA). (1992). The National Strategy for Ecologically Sustainable Development. AGPS, Canberra.
- CoA. (2007) Guidelines for the Ecologically Sustainable Management of Fisheries. 18 pp. Accessed 12 March 2013 from: <http://www.environment.gov.au/coasts/fisheries/publications/pubs/guidelines.pdf>
- DoF. (1999). Management directions for Western Australia's estuarine and marine embayment fisheries – a strategic approach to management. Fisheries Management Paper No. 131. Department of Fisheries, WA. Accessed 9 February 2015 from: http://www.fish.wa.gov.au/Documents/management_papers/fmp131.pdf
- DoF. (2002a). Policy for the Implementation of Ecologically Sustainable Development for Fisheries and Aquaculture within Western Australia. Fisheries Management Paper No. 157. Department of Fisheries, WA.

- DoF. (2002b). Report to the Minister for Agriculture, Forestry and Fisheries by the Integrated Fisheries Management Review Committee. Fisheries Management Paper No. 165. Department of Fisheries, WA. Accessed 9 February 2015 from: http://www.fish.wa.gov.au/Documents/management_papers/fmp165.pdf
- DoF. (2003). Aboriginal Fishing Strategy: Recognising the past, fishing for the future. Draft Report to the Minister for Agriculture, Forestry and Fisheries by the Hon. E.M. Franklyn QC, Chairman of the Aboriginal Fishing Strategy Working Group. Fisheries Management Paper No. 168. Department of Fisheries, WA. Accessed 9 February 2015 from: http://www.fish.wa.gov.au/Documents/management_papers/fmp168.pdf
- DoF. (2009). Integrated Fisheries Management Government Policy. http://www.fish.wa.gov.au/Documents/ifm/IFMGovtPolicy_2009.pdf
- DoF. (2010). A Sea Change for Aquatic Sustainability – Meeting the Challenge of Fish Resource and Aquatic Sustainability in the 21st Century. Fisheries Occasional Publication No. 79. Department of Fisheries, WA. Accessed 9 February 2015 from: http://www.fish.wa.gov.au/Documents/occasional_publications/fop079.pdf
- DoF. (2012a). Western Australian Government Fisheries Policy Statement March 2012. Department of Fisheries, WA, 12 pp. http://www.fish.wa.gov.au/Documents/corporate_publications/wa_govt_fisheries_policy_statement.pdf.
- DoF. (2012b). Research, Monitoring, Assessment and Development (RMAD) Plan 2011 – 2012. Fisheries Occasional Publication No. 106, Department of Fisheries, WA, 156 pp.
- DoF. (2012c). A Resource-Based Management Approach for Recreational Fishing In Western Australia 2012 - 2017. Fisheries Management Paper No. 252. Department of Fisheries, WA. Accessed 9 February 2015 from: http://www.fish.wa.gov.au/Documents/management_papers/fmp252.pdf
- DoF. (2014a). Recreational Fishing Guide 2014. Department of Fisheries, WA. http://www.fish.wa.gov.au/Documents/recreational_fishing/rec_fishing_guide/rules_guide_statewide.pdf
- Department of Fisheries (DoF). (2015a). Finfish Resources of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020. Fisheries Management Paper No. 274. Department of Fisheries, WA.
- DoF. (2015b). Blue Swimmer Crab Resource of the Peel-Harvey Estuary Harvest Strategy 2015 – 2020. Fisheries Management Paper No. 273. Department of Fisheries, WA.
- DoF. (2015c). Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia. Fisheries Management Paper No. 271. Department of Fisheries, WA.
- DoF. (in press). Research, Monitoring, Assessment and Development (RMAD) Plan 2015 – 2020. Fisheries Occasional Publication No. 122. Department of Fisheries, WA.
- Fletcher, W.J. (2005). Application of qualitative risk assessment methodology to prioritise issues for fisheries management *ICES Journal of Marine Research* 62: 1576-1587. <http://icesjms.oxfordjournals.org/content/62/8/1576.full.pdf+html>
- Fletcher, W.J. & Santoro, K. (eds). (2014). Status Reports of the Fisheries and Aquatic Resources of Western Australia 2013/14: The State of the Fisheries. Department of Fisheries, WA.

- Fletcher, W., Chesson, J., Sainsbury, K., Fisher, M., Hundloe, T. & Whitworth, B. (2002). Reporting on Ecologically Sustainable Development: A “how to guide” for fisheries in Australia. Canberra, Australia. 120 pp.
- 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.
<http://www.sciencedirect.com/science/article/pii/S0308597X10000849>
- Fletcher, W.J., Shaw, J., Gaughan, D.J. & Metcalf, S.J. (2011). Ecosystem Based Fisheries Management case study report – West Coast Bioregion. Fisheries Research Report No. 225. Department of Fisheries, WA, 116 pp.
- Fretzer, S. (2011). The Peel-Harvey Estuarine Ecosystem – system analysis and management implications. Report to the Western Australian Marine Science Institution (WAMSI) on Project 4.3.2 ‘Ecosystem modelling’. Murdoch University, WA. 16 pp.
- Green, T.J. & McKinley, J.P. (2009). Compliance program evaluation and optimisation in commercial and recreational Western Australian fisheries. Final report to the FRDC on Project No. 2001/069. Fisheries Research Report No. 195. Department of Fisheries, WA.
- Hale, J. & Butcher, R. (2007). Ecological Character Description of the Peel-Yalgorup Ramsar Site. Department of Environment and Conservation and the Peel-Harvey Catchment Council, Perth, WA.
- Harrison, N. (ed.) (1999). A Quality Future for Recreational Fishing on the West Coast. Fisheries Management Paper No. 139. Department of Fisheries, WA. Accessed 9 February 2015 from:
http://www.fish.wa.gov.au/Documents/management_papers/fmp139.pdf
- Harrison, N. (ed.) (2001). A Five-Year Management Strategy for Recreational Fishing on the West Coast of Western Australia. Fisheries Management Paper No. 153. Department of Fisheries, WA. Accessed 9 February 2015 from:
http://www.fish.wa.gov.au/Documents/management_papers/fmp153.pdf
- Henry, G. & Lyle, J. (2003). The National Recreational and Indigenous Fishing Survey. Canberra: FRDC Project No 99/158.
- IFAAC. (in prep.). Draft Allocation Report: Lower West Coast Crab Resource. Department of Fisheries, WA, 56 pp.
- Johnston, D., Chandrapavan, A., Wise, B. & Caputi N. (2014a). 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, WA, 172 pp.
- Malseed, B.E. & Sumner, N.R. (2001). 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, WA, 52 pp.
- MSC. (2013). Guidance to the MSC Certification Requirements. Version 1.3, 14 January 2013, 254 pp.
- Ryan, K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H. & Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249. Department of Fisheries, WA, 168 pp.

- Sloan, S.R., Smith, A.D.M., Gardner, C., Crosthwaite, K., Triantafillos, L., Jeffries, B. & Kimber, N. (2014). National Guidelines to Develop Fishery Harvest Strategies. FRDC Report – Project 2010/061. Primary Industries and Regions, South Australia, Adelaide.
- Valesini, F.J., Hourston, ML, Wildsmith, M.D., Coen, N.J. & Potter, I.C. (2010). New Quantative approaches for classifying and predicting local-scale habitats in estuaries. *Estuarine, Coastal and Shelf Science* 86: 645-664.
- Wilson, C. (ed.) (1997). The impact of Occupational Safety and Health on the management of Western Australian fisheries. Fisheries Management Report No 1. Department of Fisheries, WA.

15. Appendices

Appendix A – Blue Swimmer Crab Research Summary

In addition to comparing the annual commercial catch and standardised catch rates against specified reference points, the status of blue swimmer crabs in the PHE is determined using a weight-of-evidence approach with a range of other available data. A summary data available from commercial monitoring and fishery-independent surveys are presented below.

Commercial Monitoring

Changes in the sex composition of catches through time

Although gillnetting for crabs was historically undertaken mainly during the summer, since the conversion to traps there has been an increase in fishing effort during autumn and winter when the proportion of females in the catch is higher.

Commercial monitoring between 1998 and 2001 and between 2007 and 2014 shows that males dominate catches during summer months (weight-of-evidence approach), with females increasing to ~ 50 % of the catch during April-June (Figures 1 and 2). July was notably different between the current and historical surveys, with males dominating catches in July and August in 1998 – 2001 and female catch rates < 0.2 crabs / traplift (Figure 1). In comparison, up to one female crab / traplift was landed in July between 2007 and 2014. Catches were relatively evenly divided between males and females from July through to October between 2007 and 2014 (Figure 2). This may be due to the timing of female migration out of the estuary driven by changes in rainfall patterns over the last decade, with females remaining in the estuary for longer.

The catch rates of berried females were very low for both time series, as berried females usually leave the estuary to spawn offshore. During the 1998 – 2001 period, some berried females were present during October (14 %), November (41 %) and January (11 %), while during the 2007 – 2014 period, more berried females appeared in November (60 %) and December (30 %).

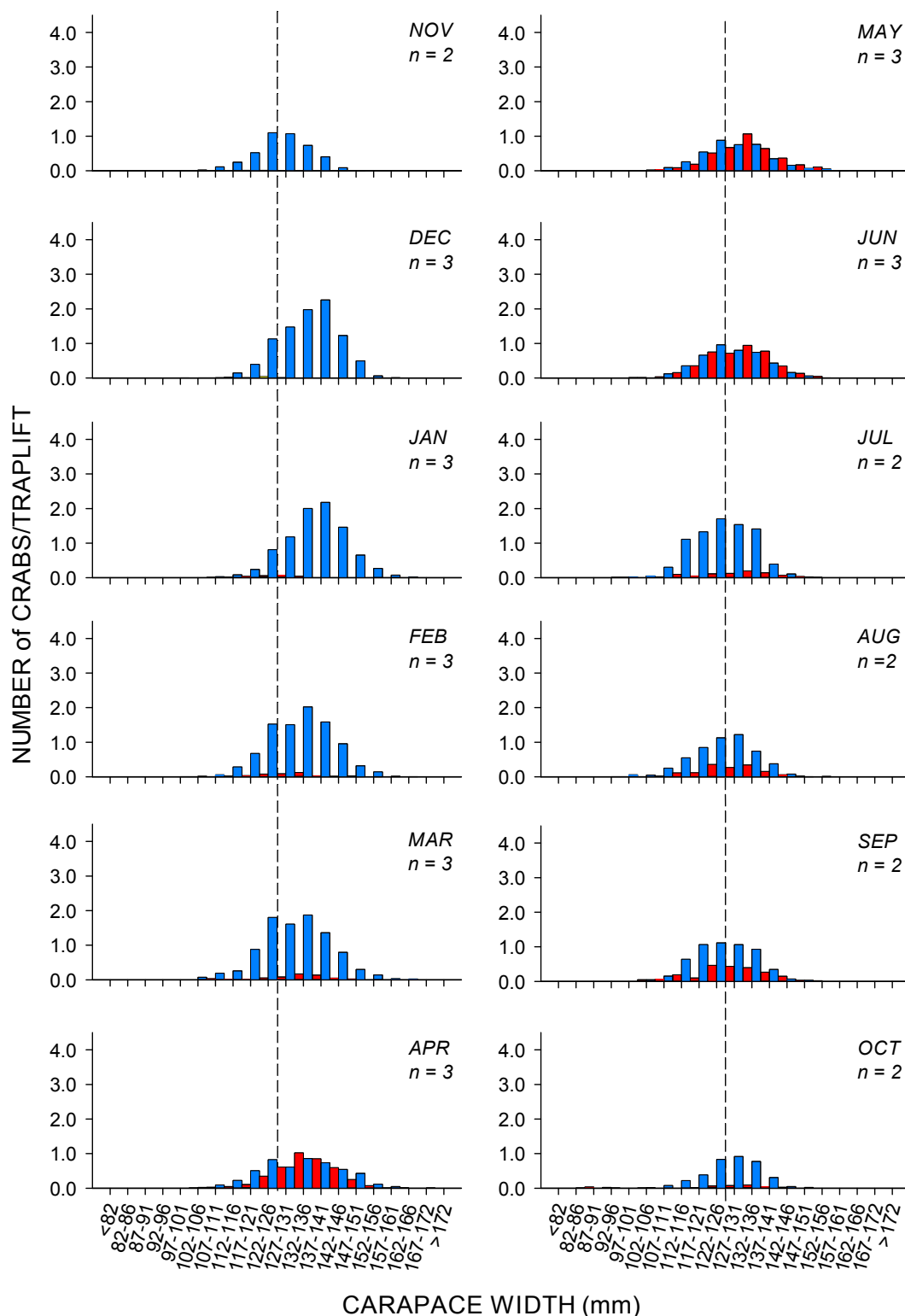


Figure 1. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from commercial catch monitoring surveys in the PHE between December 1998 and June 2001 inclusive (Melville-Smith *et al.* 2001). The dashed line denotes the minimum commercial size limit of 127 mm CW. Data is presented over the fishing season November to October and *n* represents the number of years sampled.

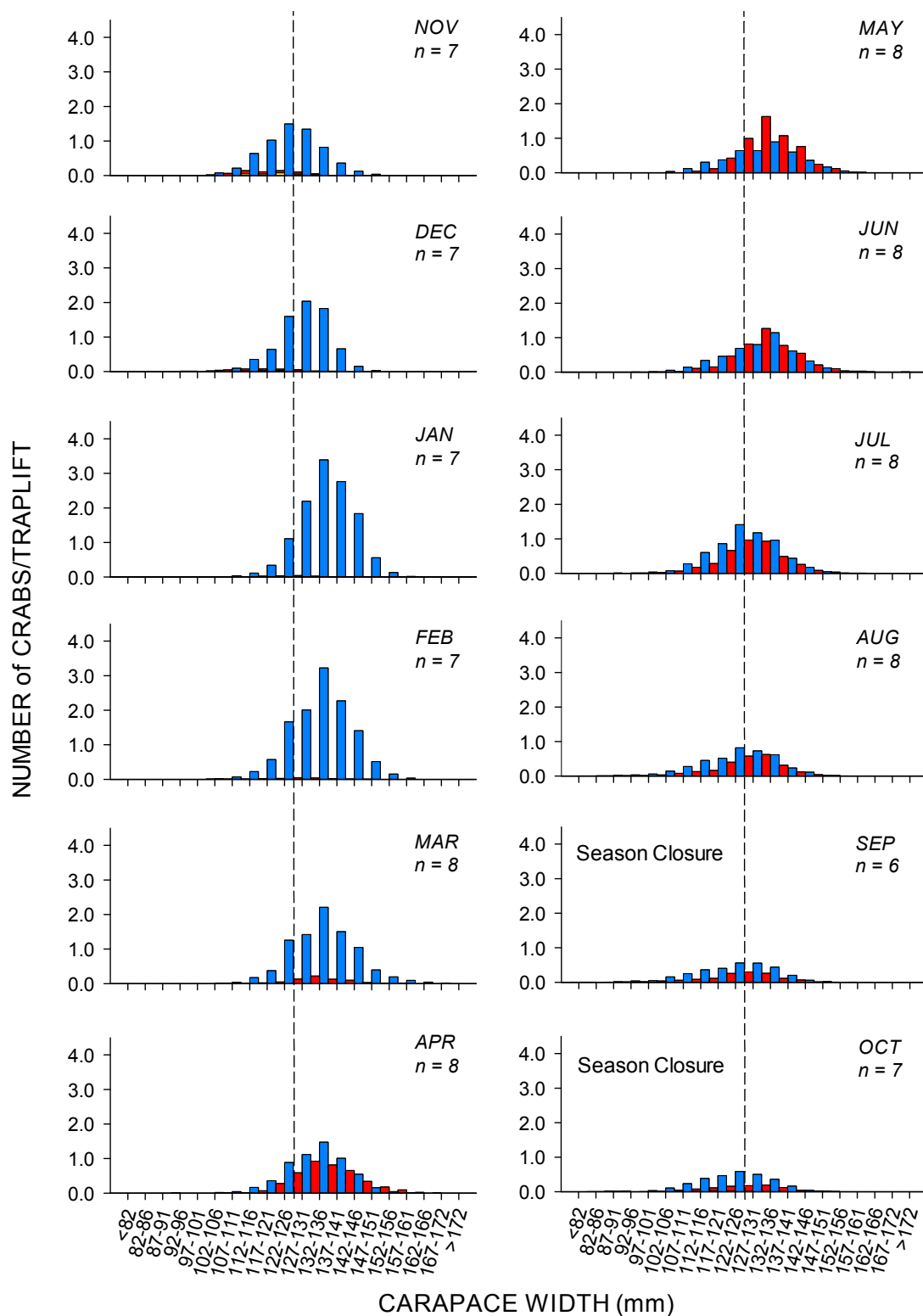


Figure 2. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from catch monitoring surveys in the PHE between March 2007 and November 2014 inclusive. Data from September – October was collected on a leased commercial vessel depending on the season arrangements for each year. The dashed line denotes the minimum commercial size limit of 127 mm CW. Data is presented over the fishing season November to October and *n* represents the number of years sampled.

In 2012/13, males dominated the catch over summer and females entered the catches in March and became prominent from April through to October (Figure 3). However, females dominated the catch in May (70 %) and August (66 %) of 2013 (Figure 3), which is unlike any previous monitoring year. There appears to be a trend where the number of months that female proportions are high in the catch is increasing from when historical commercial catch monitoring occurred 1998 – 2001 (three months — April, May and June), to current commercial monitoring 2007 – 2013 (five months April — August), with 2012/13 being the first season that females dominated the catch (> 50 %) in four months (May – August).

During the 2013/14 fishing season, females entered the fishery later than previously observed with males dominating through the summer and into April (Figure 4). Females were the dominant sex in May and by June the catch was evenly distributed between males and females, with males becoming the dominant sex from July (Figure 4). Although the proportion of females in July and August of 2013/14 were significantly lower than previous monitoring years, most likely due to early winter rainfall (Figure 4), there appears to be an overall trend that indicates an increasing pressure on mated pre-spawn females as females moult and mate in April and are able to be retained during this period (as they are not berried until September).

In 2013/14, commercial monitoring data indicated that a greater proportion of female blue swimmer crabs congregated in the south west area of Peel Inlet, whereas males tend to be more prevalent in the Harvey Estuary (Figure 5). This may reflect seasonal fishing patterns, which become concentrated around the entrance to Dawesville Channel during winter, coinciding with the movement of female crabs out of the estuary with the winter rains to spawn. This increased proportion of mated pre-spawn females in the catch needs to be monitored closely to ensure the sustainability of the blue swimmer crab stock in the PHE.

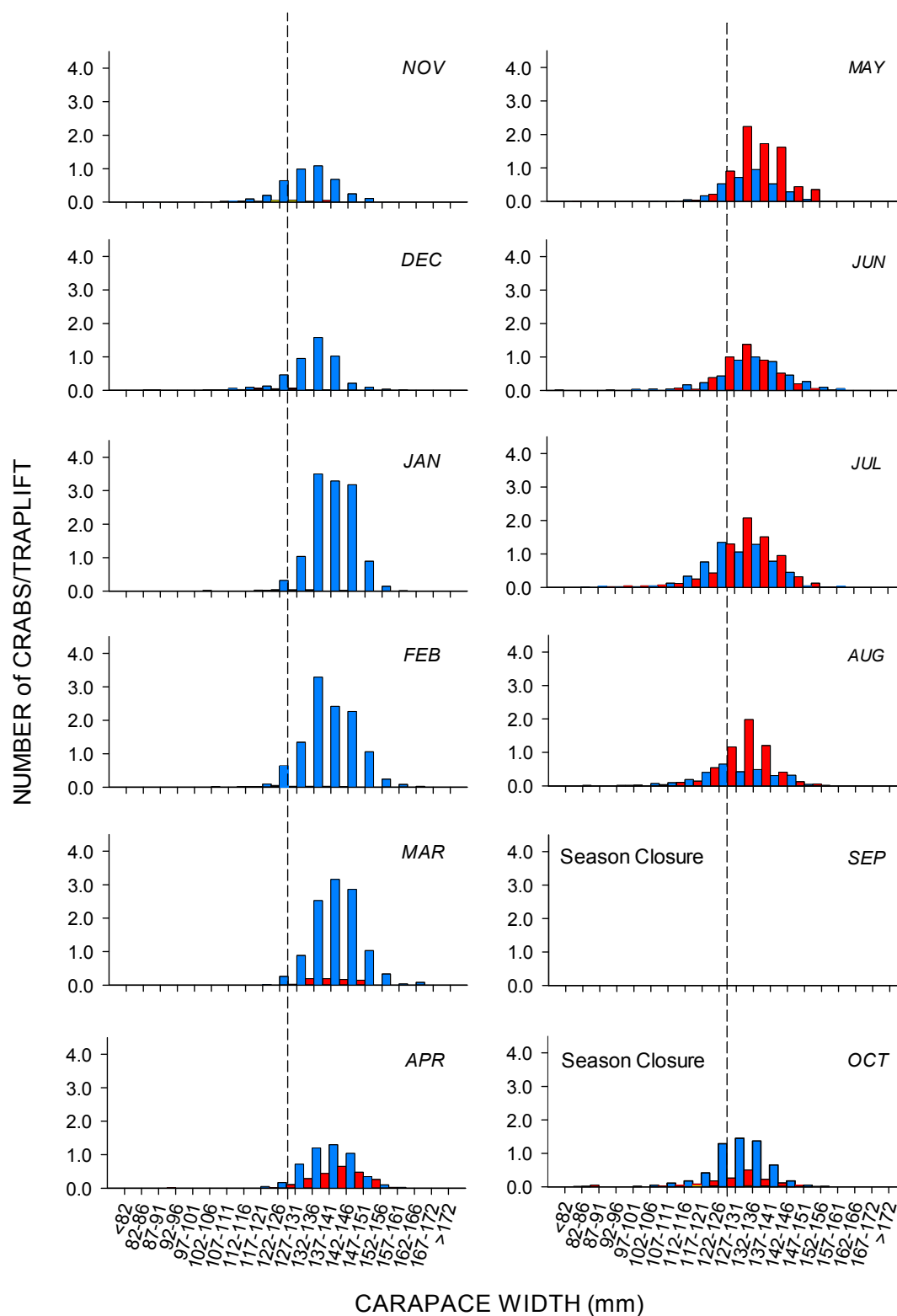


Figure 3. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from catch monitoring surveys in the PHE between November 2012 and October 2013 inclusive. Data from October was collected from two surveys by local commercial operators acting in a voluntary capacity. The dashed line denotes the minimum commercial size limit of 127 mm CW. Data is presented over the fishing season November to October.

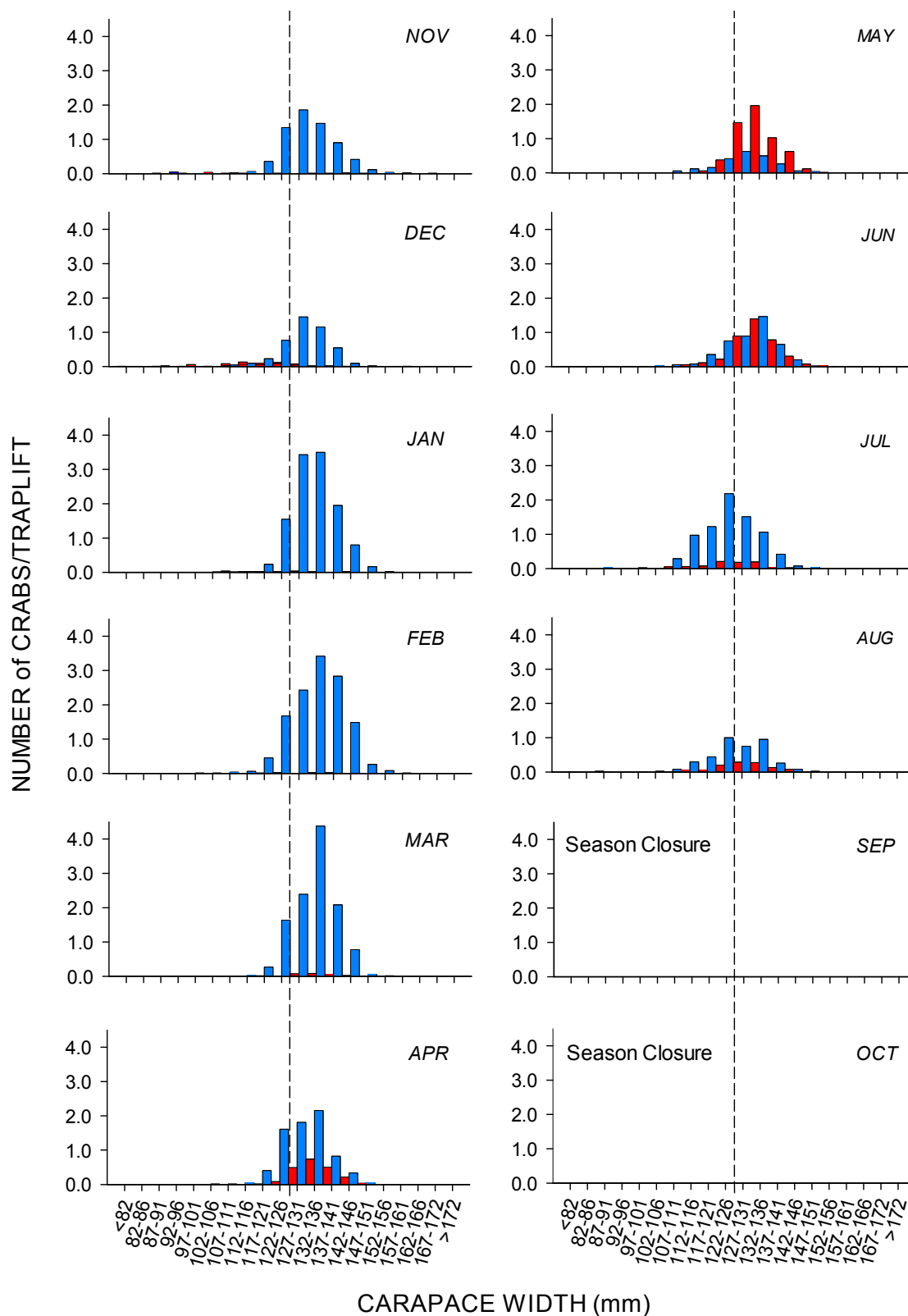


Figure 4. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from catch monitoring surveys in the PHE between November 2013 and August 2014 inclusive. The dashed line denotes the minimum commercial size limit of 127 mm CW. Data is presented over the fishing season November to October.

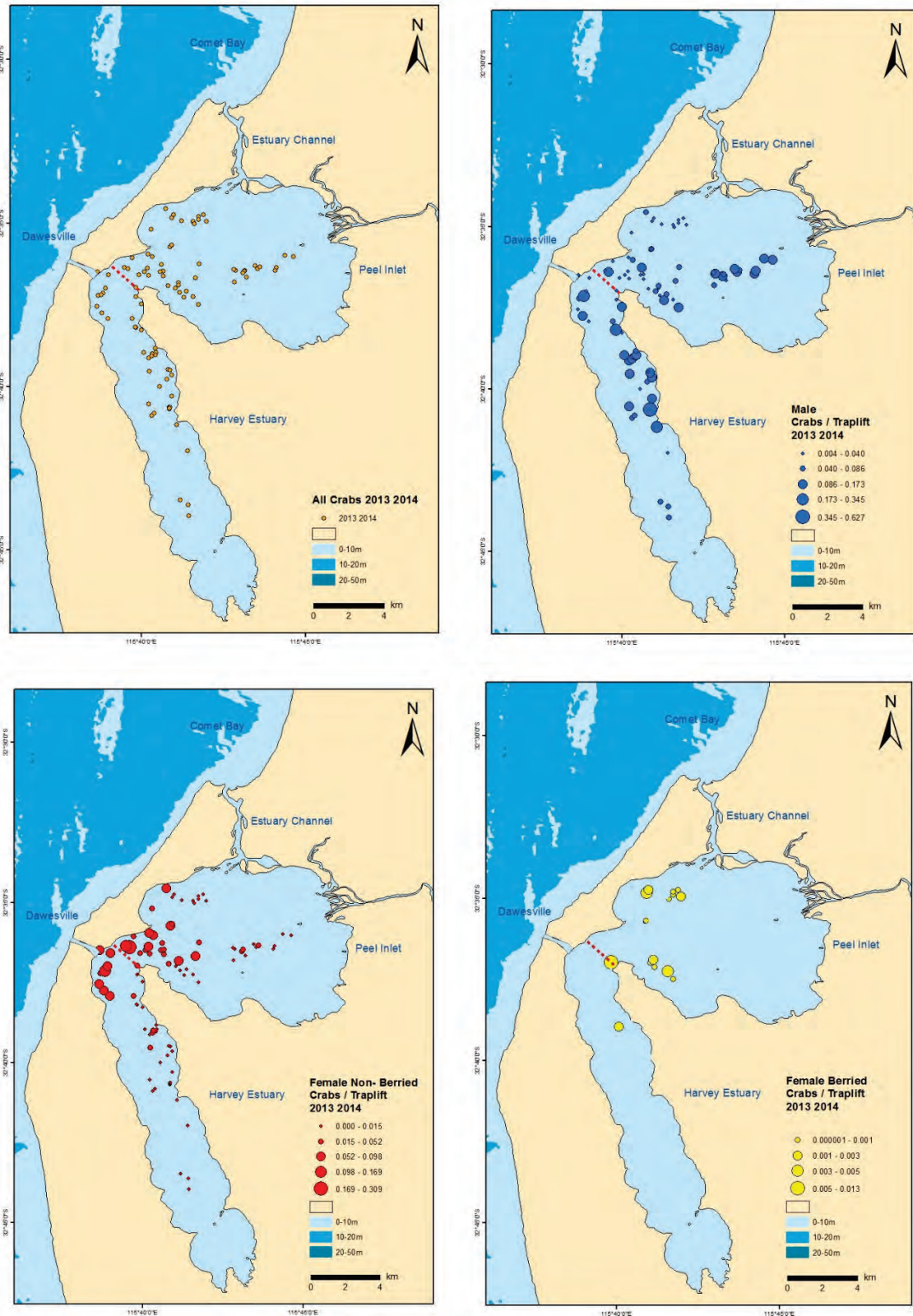


Figure 5. Density plots showing spatial distributions of male, female and ovigerous female crab data collected during commercial catch monitoring surveys aboard commercial vessels in the WCEMF Area 2 between July 2013 and June 2014. For ease of visibility, the scales for each category vary due to the large difference in numbers of each sex category caught.

Changes in the size distribution of catches through time

Mean monthly size distributions of crabs caught during commercial monitoring since 2007/08 show that blue swimmer crabs are generally undersize (< 127 mm CW) at the beginning of each commercial fishing season in November, with the exception of 2013/14 when crabs were approximately 128-129 mm CW (Figure 6). As crabs move into the PHE and moult over summer, the size of crabs increases peaking in the summer months followed by a depletion of the large crabs through the season with smaller size crabs dominating the catch from July. The overall size of crabs varies between years with 2008/09 being characterised by small-sized crabs. This was consistent with observations at the time and was a key factor contributing to the low catch that year with high catch rates of sub-legal crabs not moulting through to legal size. Similarly 2011/12 and 2012/13 had the largest crabs reported during the time period with record high catches in these years.

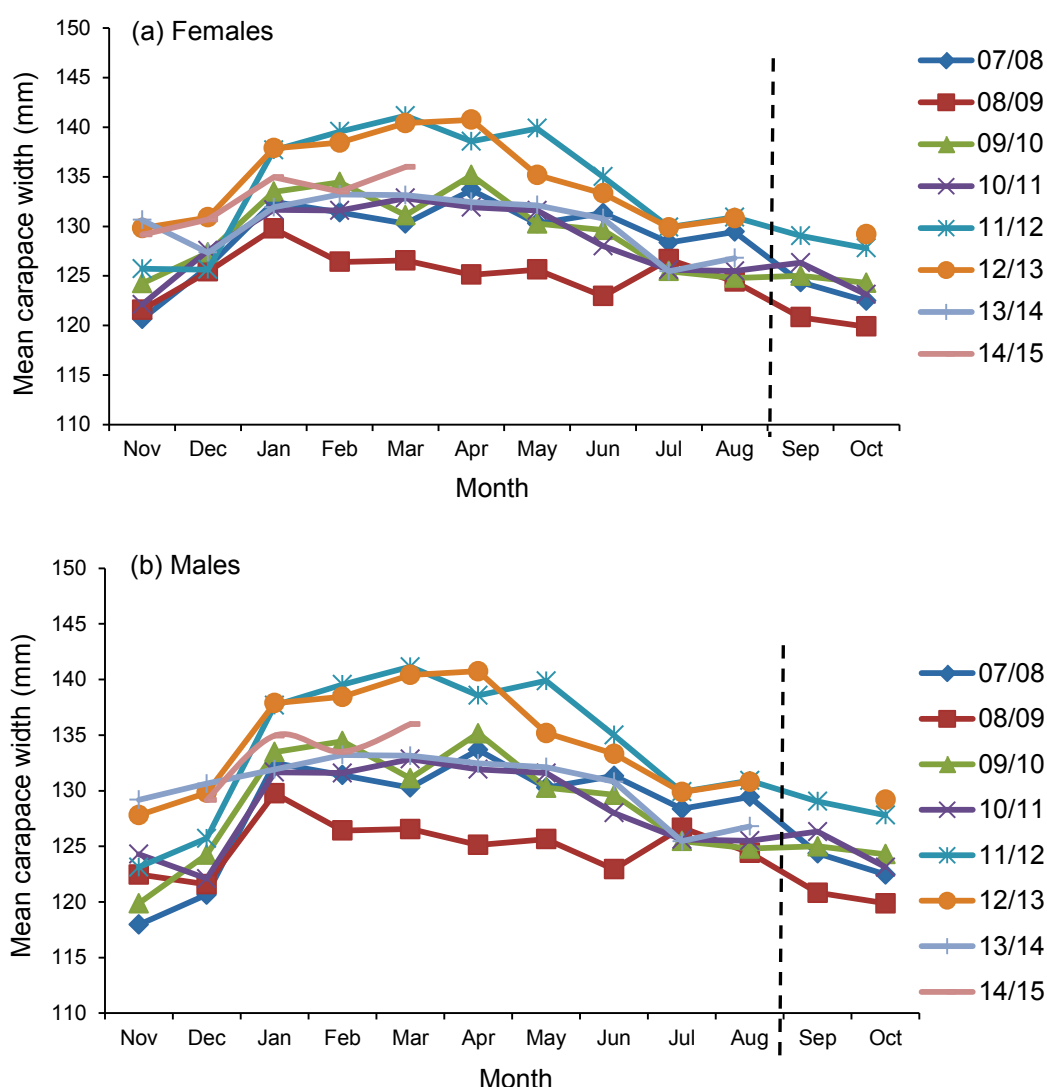


Figure 6. Mean monthly carapace width (mm) of (a) female and (b) male blue swimmer crabs from commercial monitoring data collected in each fishing season of the WCEMF Area 2 between 2007/08 and 2014/15.

It is evident that the overall size of crabs caught in commercial traps has increased between 2007/08 and 2014/15 (Figure 7). Whilst large crabs did dominate the fishery in some years (2011/12 and 2012/13) this overall trend is most likely due to targeting of larger individuals and an increase in the number of fishers adding escape gaps to their traps. Voluntary escape gaps were adopted in the fishery around 2005 with steady increase in fishers using escape gaps up to 100 % in recent years. The drop in mean size in 2008/09 was due to a large cohort of undersize crabs in the fishery that year.

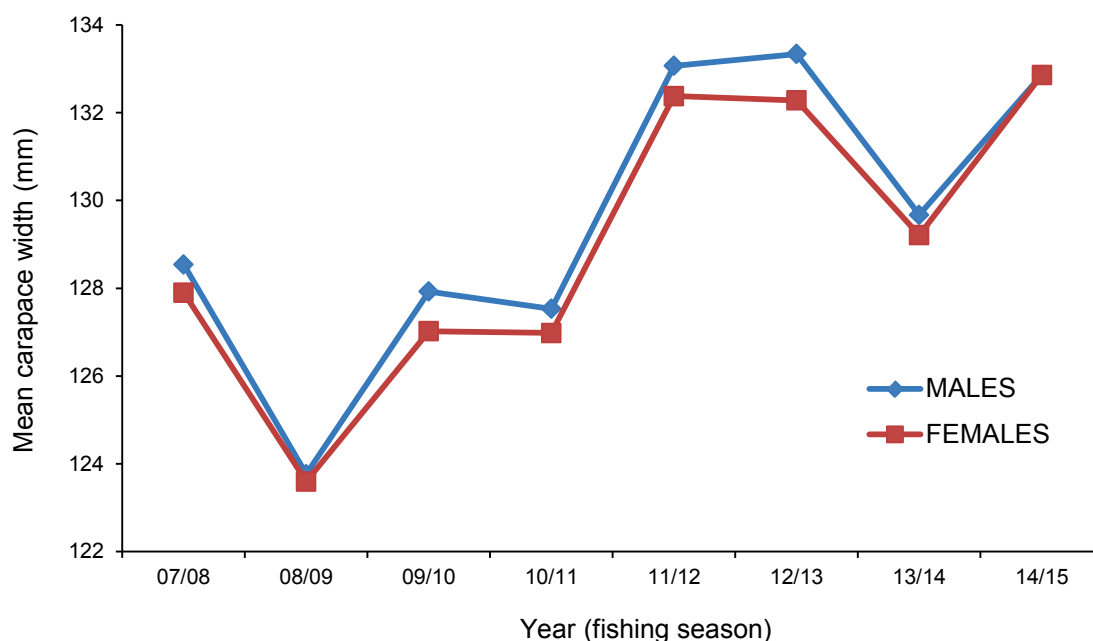


Figure 7. Mean annual carapace width of female and male blue swimmer crabs from commercial monitoring data collected in each fishing season of the WCEMF Area 2 between 2007/08 and 2014/15.

The size composition of blue swimmer crab catches in the fishery has not changed significantly between 2007/08 and 2014/15, with no evidence of overfishing large sized crabs (Figures 8 and 9). It is evident that the number of small crabs in commercial traps has decreased during this time period due to the use of escape gaps by fishers. Berried female crabs are evident between the sizes of 110-135 mm CW, however numbers are low with the majority of berried crabs being flushed out of the estuary during winter (Figures 8 and 9).

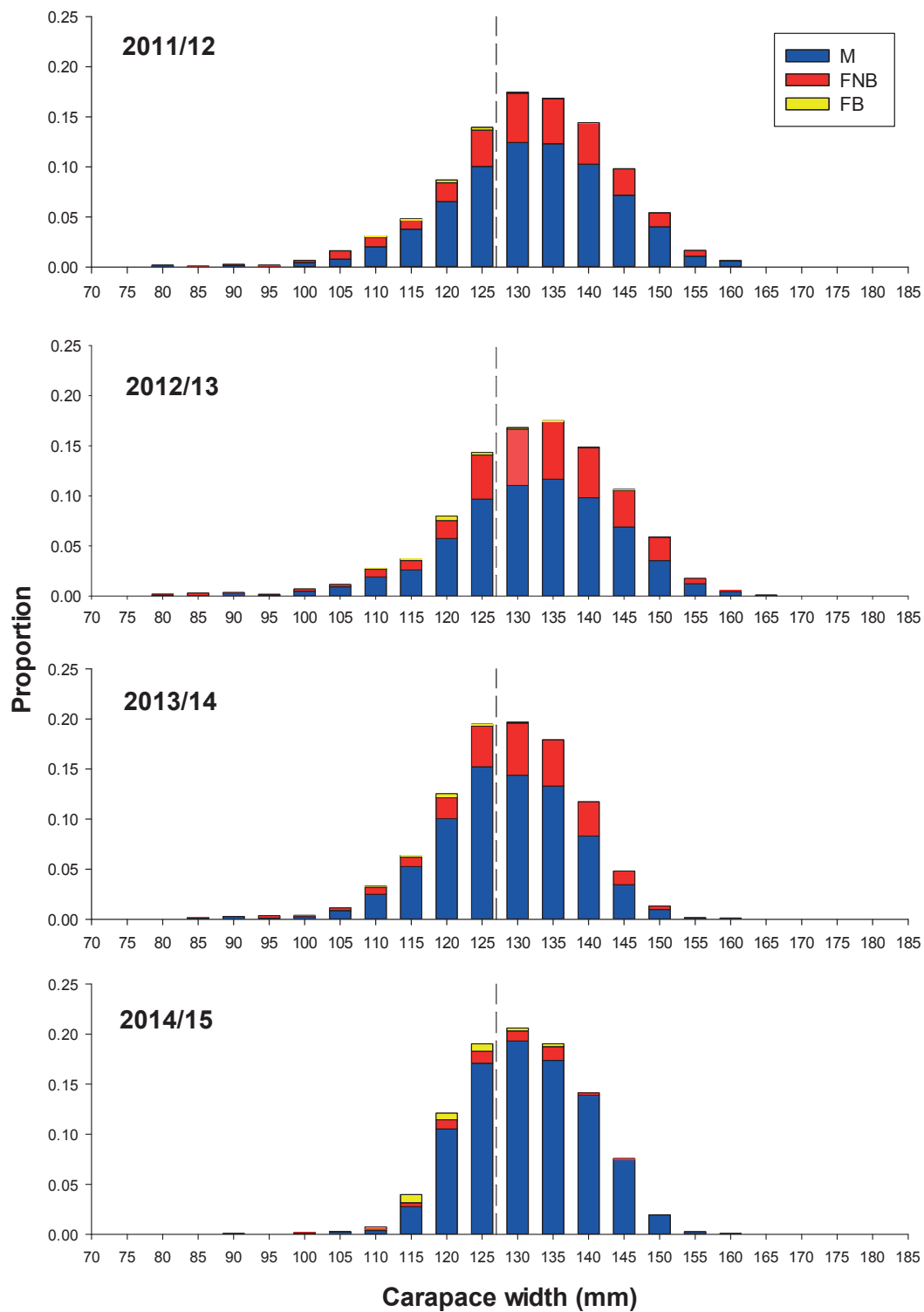


Figure 9. Annual size distributions of male (M, blue) and female non-berried (FNB, red) and female berried (FB, yellow) blue swimmer crabs from commercial monitoring data collected in each fishing season of the WCEMF Area 2 between 2011/12 and 2014/15.

Fishery-Independent Monitoring

The size (carapace width - CW) distributions of catches from fishery-independent research surveys undertaken since 2007 are generally unimodal although there are distinct differences in sex ratios and sizes of blue swimmer crabs for corresponding months between the inside PHE sites, the Estuary Channel sites and the outside oceanic sites (Figures 10-12). A large proportion of captured crabs from inside the Peel Harvey and Channel sites are sub-legal (< 127 mm CW).

Catches inside PHE are male dominated for the entire year with a maximum catch rate of 3.0 crabs / trawl for any size-class during summer months, while female (non-berried) catch rates are highly variable and generally less than 1.0 crab / trawl (Figure 10). The new recruit cohort is evident from June - October (Figure 10). In contrast, the catch composition from the Estuary Channel sites shows equal sex ratios for most size classes, with catch rates reaching 2.5 crabs / trawl for some size classes (Figure 11). Notably the catch rate of legal-sized females exceeds males in May and June. Due to the influx of oceanic water in the Estuary Channel, there are ovigerous females present from October to January. New recruits are again present after June.

The size distributions from the outside oceanic sites show low catch rates of blue swimmer crabs, generally below 1.0 crab / trawl for all size classes. Females tend to dominate the catch composition throughout the year with an increasing trend of legal sized females from April - September (Figure 12). Ovigerous females are not detectable from the inside PHE sites but higher catch rates have been recorded between October - January from the Estuary Channel sites and the outside oceanic sites; further evidence that females migrate outside of the estuary to spawn. As of 2012, no ongoing monitoring has been undertaken in these oceanic waters as sampling may not portray an accurate abundance of crab populations outside the estuary.

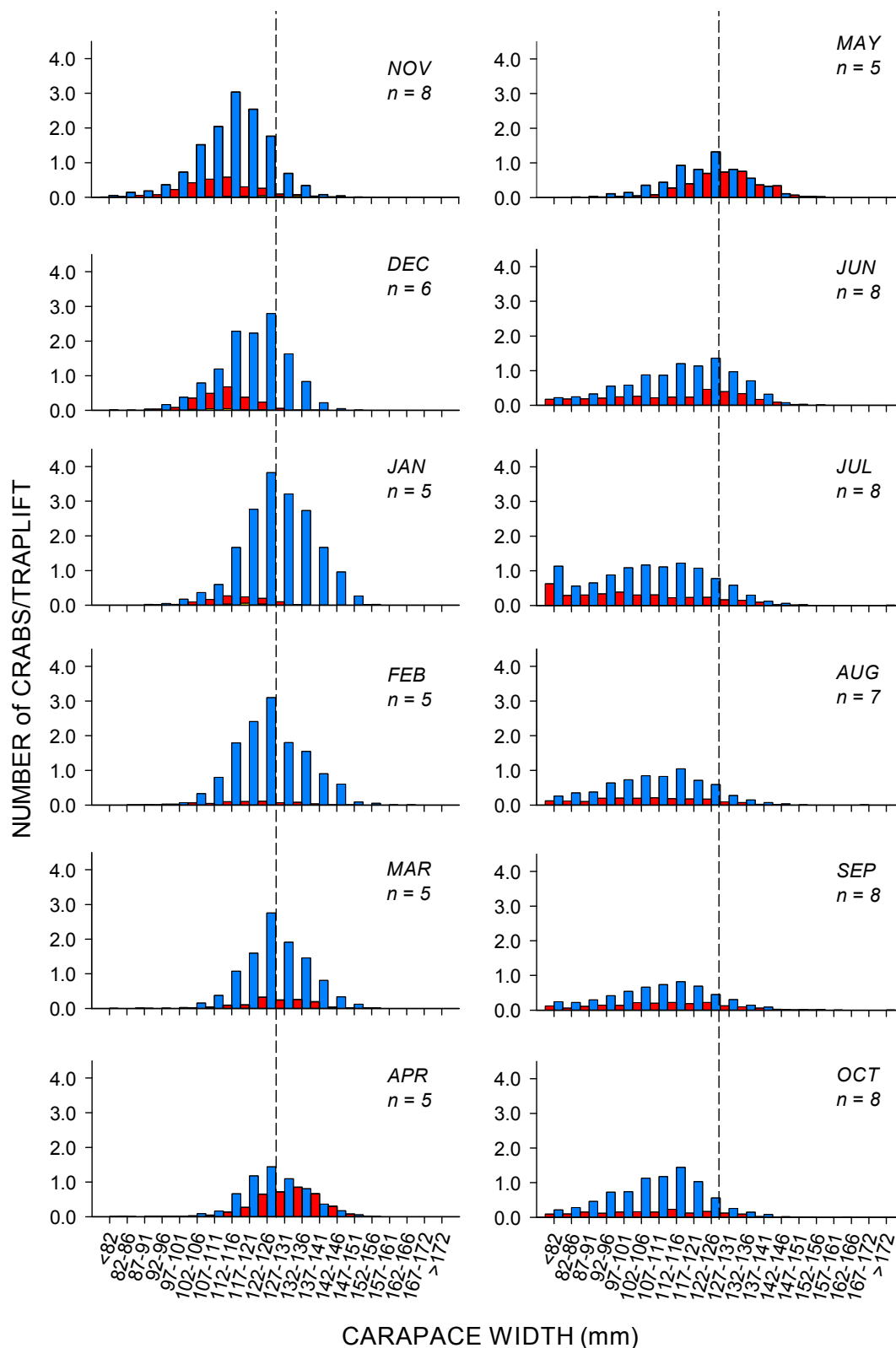


Figure 10. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from fishery-independent research trap surveys in the PHE (excluding Estuary Channel and oceanic sites) between June 2007 and November 2014 inclusive. Minimum commercial size limit of 127 mm CW (- - -). Data is presented over the fishing season; November to October and *n* represents the number of years sampled.

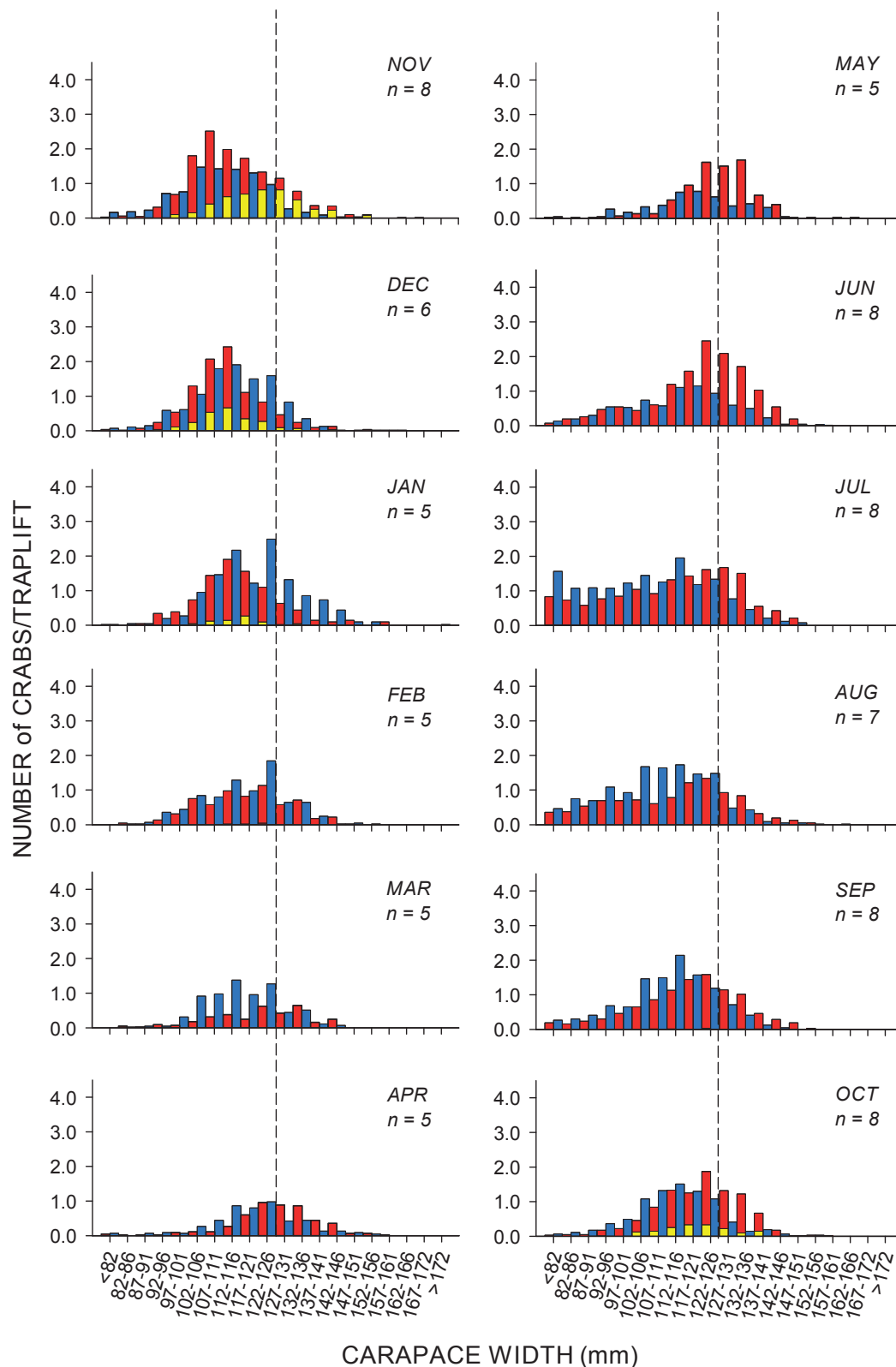


Figure 11. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from fishery-independent research trap surveys in the Estuary Channel of the PHE between June 2007 and November 2014 inclusive. Minimum commercial size limit of 127 mm CW (---). Note that the Estuary Channel is a no fishing zone. Data is presented over the fishing season; November to October and *n* represents the number of years sampled.

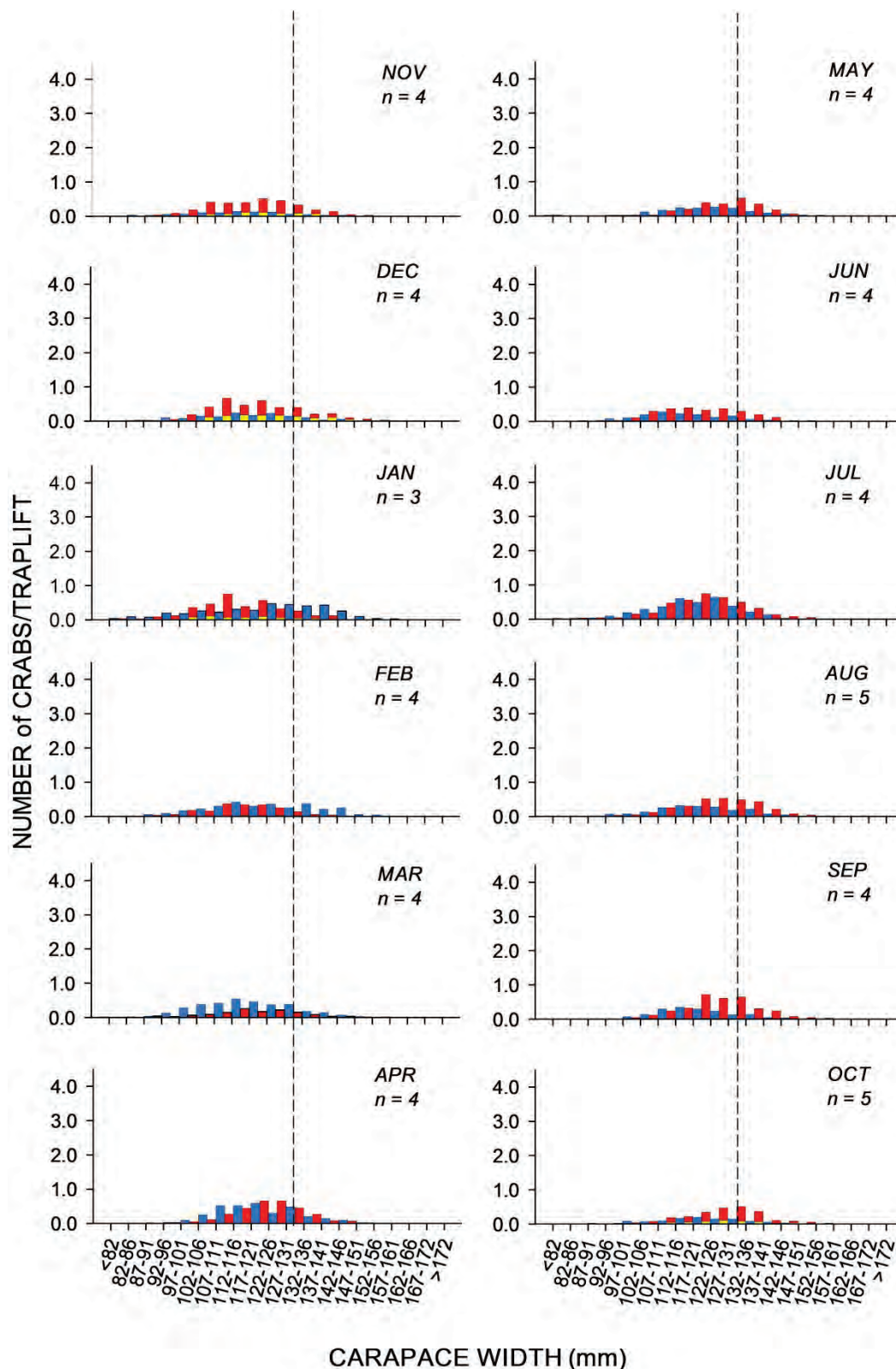


Figure 12. Mean monthly size distributions of male (■), female (■), and ovigerous female (■) blue swimmer crabs from fishery-independent research trap surveys in the oceanic waters immediately outside the PHE between August 2008 and October 2012 inclusive. Minimum commercial size limit of 127 mm CW (---). Data is presented over the fishing season; November to October and *n* represents the number of years sampled.

Appendix B – 2014-15 Ecological Risk Assessments

Productivity Susceptibility Analysis (PSA)

The PSA approach is based on the assumption that the risk to a species depends on two characteristics: (1) the extent of the impact due to the fishing activity, which will be determined by the susceptibility to the fishing activities (Susceptibility) and (2) the productivity of the species (Productivity), which will determine the capacity of the stock to recover if the population is depleted.

Productivity analysis is determined by the species life history traits i.e. growth and maturity characteristics, trophic level and fecundity (Table 1). While susceptibility is calculated using the overlap of the fishing area compared with the species range (geographical spread and depth/habitat overlap) the probability of capture if the fishing gear is encountered (e.g. species size v mesh size) and the likelihood of post capture survival (Table 2). There are 7 productivity categories and 4 susceptibility categories. The scores for productivity are combined with susceptibility scores to produce a risk score. PSA scores are divided into low risk (i.e. <60), medium risk (i.e. 60-80) and high risk (i.e. >80).

Table 1. MSC PSA productivity attributes and scores.

Productivity determinant	Low productivity (high risk score =3)	Medium productivity (medium risk score =2)	High productivity (low risk score =1)
Average age at maturity	15 years	5-15 years	5 years
Average maximum age	25 years	10-25 years	10 years
Fecundity	<100 eggs per year	100-20 000 eggs per year	>20 000 eggs per year
Average maximum size	>300cm	100-300cm	<100cm
Average maximum size at maturity	>200cm	40-200cm	<40cm
Reproductive strategy	Live bearer	Demersal egg layer	Broadcast spawner
Trophic level	>3.25	2.75-3.25	<2.75

Table 2. MSC PSA susceptibility attributes and scores.

Susceptibility determinant	Low susceptibility (Low risk =1)	Medium susceptibility (Medium risk =2)	High susceptibility (High risk =3)
Areal overlap (Overlap of the fishing effort with a species distribution of the stock)	<10% overlap	10-30% overlap	>30% overlap
Vertical overlap (Position of the stock/species within the water column relative to the fishing gear)	Low overlap with fishing gear	Medium overlap with fishing gear	High overlap with fishing gear
Selectivity			
Selectivity for set gillnets – The potential of gear to capture or retain the species	Length at maturity < mesh size or >5m in length	Length at maturity is 1-2 times mesh size or 4-5m in length	Length at maturity >2 times mesh size 4m in length
Selectivity for hooks – Defined by typical weights of the species caught relative to the breaking strain of the snood, the gaffing method used in the fishery and by the diet of the potential species (Scores for hook susceptibility may be assigned using the categories to the right. If there are conflicting answers e.g. low on point 1 but medium on point 2, the higher risk score shall be used.)	a. Does not eat bait (e.g. diet specialist) filter feeder (e.g. basking shark) small mouth (e.g. sea horse) Most robust scoring attribute b. Species with capacity to break line when hooked (e.g. large toothed whales and sharks) c. selectivity unknown to be low from selectivity analysis/experiment (e.g. <33% of fish encountering gear are selected)	a. Large species, with adults rarely caught, but juveniles captured. b. Species with capacity to break snood when being landed. c. selectivity known to be medium from selectivity analysis/experiment (e.g. 33-66% of fish encountering gear are selected)	a. Bait used in the fishery is selected for this type of species and is a known diet preference (e.g. squid bait used for swordfish) or important in wild diet. b. Species unable to break snood when being landed c. selectivity known to be high from selectivity analysis/experiment (e.g. >66% of fish encountering gear are selected)
Selectivity for traps/pots – (Scores for trap susceptibility may be assigned using the categories to the right. If there are conflicting answers e.g. low on point 1 but medium on point 2 the higher risk score shall be used.)	a. Cannot physically enter the trap (e.g. too big for openings, sessile species wrong shape etc.) b. Can enter and easily escape from the trap and no incentive to enter the trap (does not eat bait, trap is not attractive as habitat etc.)	a. Can enter and easily escape from the trap but is attracted to the trap (e.g. does eat the bait, or trap is attractive as habitat) b. Can enter but cannot easily escape from the trap and no incentive to enter the trap (does not eat bait, trap is not attractive as habitat etc.) c. Species occasionally found in trap	a. Can enter but cannot easily escape from the trap and is attracted to either the bait or the habitat provided by the trap. b. Species regularly found in trap
Post capture mortality	Evidence of post capture release and survival	Released alive	Retained species or majority dead when released

Commercial Net Fishery in the PHE

Introduction and Methods

In the Peel-Harvey Estuary, sea mullet are fished as a part of the WCEMF Area 2. The WCEMF has a number of management procedures in place to assess and mitigate the potential impacts on target, byproduct, by catch and ETPs. These include ecological risk assessments (ERA), spatial closures, temporal and seasonal closures, limited entry, effort controls, gear restrictions and compulsory reporting.

To assess the risk to all target, retained and bycatch species within the WCEMF netting finfish fishery, a PSA was conducted. The PSA assessment was undertaken for all retained species including those < 5 % of the total catch (Table 3). In the Peel-Harvey Estuary almost the entire catch by the WCEMF is retained, with little or no bycatch. A list of potential bycatch species was generated from species recorded during surveys of the commercial blue swimmer crab trap fishery in the Peel-Harvey Estuary.

Information for productivity scores was based on fishbase⁶⁵, the Australian Government Department of the Environment's Species Profile database⁶⁶ and published peer-reviewed literature. Where productivity attributes for a particular species were not available values for a similar species (in the same family) were used. If no productivity scores were available a precautionary approach was used and species were assigned the most conservative score. In some cases, where species identifications were uncertain similar species were grouped together. In these cases, the most conservative score was applied across the group i.e. skates.

A summary of the information used to justify the productivity and selectivity scores is provided in Table 4.

Results

The results from the PSA with the individual scores for each attribute and a total PSA score and risk rating is provided in Table 5. The PSA risk rating for most of the retained and bycatch species was low (Table 5). Two species were assessed as medium risk; cobbler (*Cnidoglanis macrocephalus*) and Perth herring (*Nematalosa vlaminghi*). None were identified as high risk.

Cobbler (*Cnidoglanis macrocephalus*)

The risk rating for cobbler was generated from medium productivity (lays relatively low number of eggs demersally) and high susceptibility scores (restricted distribution, mainly in estuaries).

Perth herring (*Nematalosa vlaminghi*)

The medium risk rating for Perth herring was mainly attributed to the restricted distribution of this species.

⁶⁵ www.fishbase.org

⁶⁶ <http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl>

Table 3. All retained species (kg) for the Peel-Harvey Estuary (net) Fishery 2000 – 2013. Dark blue indicates target (P1) species, and light blue indicates primary byproduct species (> 5 % total net catch based on five-year average catches 2008 – 2012); * indicates species is monitored as an indicator species for the WCB estuarine finfish suite (DoF 2011).

Species	Catch (kg)													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Sea mullet	45674	61316	59296	61018	61968	49053	52774	62142	50240	63489	70298	48342	55731	67780
Yellow-eye mullet	37020	46269	23296	32610	46076	32756	26912	30746	25348	25852	24317	14614	20558	16596
Yellowfin whiting	8152	4661	10814	9275	9019	12163	9097	4995	10291	9367	10497	8131	10418	13954
Tailor	8533	4606	3266	2063	1159	1540	765	1451	1037	6173	4150	5440	8191	12668
Cobbler*	4565	1317	2110	1421	1270	2860	563	498	6638	9235	5418	7423	5214	1754
Australian herring	7058	3537	3360	6410	3808	9339	9012	8324	6413	9289	5076	6158	3177	2808
Trevally, other (skippy)	53	0	0	0	0	78	79	243	512	1373	1530	1569	1551	1813
Perth herring*	1769	950	622	2036	1234	2677	1111	220	714	1567	38	356	978	1525
King George whiting	7044	1108	4016	4825	1556	2406	1953	772	3782	1798	5138	3588	185	26
Black bream*	42	0	0	0	0	0	10	5	0	0	0	3	53	266
Whiting, other	0	0	0	0	0	0	0	0	67	66	2201	3196	51	1067
Skipjack trevally	0	0	0	30	0	0	0	100	186	476	1630	0	20	0
Flathead, other	0	0	0	0	0	0	0	0	30	32	3	66	3	13
Blue swimmer crab	0	0	0	160	0	0	0	0	0	0	0	0	0	0
Sea garfish	12	0	0	0	252	287	45	0	0	19	262	0	0	0
Leatherjacket	0	0	90	0	0	0	0	0	85	0	0	0	0	0
Octopus	0	0	0	0	0	0	48	7	0	0	0	0	0	0
Other fish varieties	0	0	0	0	0	0	0	0	2	0	6	0	0	0
Pilchard	0	0	0	0	0	1021	0	0	120	0	0	30	0	0
Western king prawn	55	0	0	0	0	0	0	0	0	0	0	0	0	0
Roach	0	0	0	0	0	6	0	0	1	0	13	3	0	73
WA salmon	0	7	0	0	0	0	4	238	450	424	0	0	0	0
Yellowtail scad	0	0	0	0	0	0	0	0	0	0	0	450	0	0
Skates and rays, other	0	0	0	0	0	86	14	0	0	0	0	0	0	0
Squid	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Trumpeters	0	0	0	0	0	0	0	0	0	6	0	0	0	0
Whitebait	129	0	0	0	0	0	0	0	0	0	0	0	0	0
Mulloway	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Giant herring	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Flounders	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Total	120106	123771	106870	119848	126342	114272	102388	109741	105916	129166	130577	99369	106130	120367

Table 4. Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for sea mullet in the Peel-Harvey Estuary. Dark blue indicates target (P1) species, and light blue indicates primary byproduct species (> 5 % total net catch based on five-year average catches 2008 – 2012).

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer, LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Retained species												
Sea mullet (<i>Mugil cephalus</i>)	3-4 yrs	13 yrs	1,600,000 to 4,800,000	60-79 cm	37.3 cm	BS	2.5 + 0.17	Low	High	High	High	Source: Hutchins and Swainston 1986 Smith & Deguara 2002 Gaughan <i>et al.</i> 2006 Smallwood <i>et al.</i> 2013 www.fishbase.org
Yelloweye mullet (<i>Aldrichetta forsteri</i>)	2-3 yrs	7 yrs	125,000 to 630,000	50 cm	24.9 cm	BS	2.5 + 0.26	Low	High	High	High	Source: Chubb <i>et al.</i> 1981 Smallwood <i>et al.</i> 2013 www.fishbase.org
Yellowfin whiting (<i>Sillago schomburgkii</i>)	2 yr	12 yrs	117,000 to 217,000	41.4 cm	20 cm M 22.5 cm F	BS	3.2 + 0.2	Low	High	High	High	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org/
² Tailor (<i>Pomatomus saltatrix</i>)	2 yr	10 yrs	600,000 to 2,000,000	130 cm	35-45 cm M/F	BS	4.5 + 0.3	Low	High	High	High	Source: www.fishbase.org/ www.sms.si.edu/irlspec/pomatom_saltat.htm Smallwood <i>et al.</i> 2013
¹ Cobbler (<i>Cnidoglanis macrocephalus</i>)	3-4 yr	13 yrs	500 – 3,500	91 cm	38.5 cm M 40.5 cm F	DEL	2.8 + 0.32	High	High	Med	High	Source: Department of Fisheries Fact Sheet (27) Nel <i>et al.</i> 1985 Smallwood <i>et al.</i> 2013 Chuwen <i>et al.</i> 2011. www.fishbase.org Notes: Selectivity is rated as medium due to morphology of cobbler (round body), lack of large scales and lower catchability of smaller individuals (Chuwen <i>et al.</i> 2011)
² Australian herring (<i>Arripis georgianus</i>)	1.8 yrs M 2.2 yrs F	12 yrs	32,000 - 207,000	41 cm	17.4 cm M 19.4 cm F	BS	4.3 + 0.6	Low	High	High	High	Source: Smith and Brown 2014 Smallwood <i>et al.</i> 2013 www.fishbase.org

Table 4 (cont.). Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for sea mullet in the Peel-Harvey Estuary.

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Trevally, other (skippy) (<i>Pseudocaranx georgianus</i>)	3 yrs	18 yrs	30,000 - 220,000	93.8 cm	28 – 37 cm M/F	BS	3.9 + 0.6	Low	High	High	High	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
¹ Perth herring (<i>Nematalosa vlaminghi</i>)	3 yrs	18 yrs	Variable 15,775-480,000	36 cm	<40 cm	BS	3.4 + 0.45	Med	High	High	High	Source: Chubb and Potter 1986 www.fishbase.org Kim Smith (DoF) pers. comm. Notes: Endemic to Western Australia
King George whiting (<i>Sillaginodes punctata</i>)	3-5 yrs	14-17 yr	100,000-800,000	72.0 cm	41.0 cm F 43.7 cm M	BS	3.3 + 0.3	Low	High	High	High	Source: Brown <i>et al.</i> 2013 Smallwood <i>et al.</i> 2013 www.fishbase.org
¹ Black bream (<i>Acanthopagrus butcheri</i>)	2-3 yrs	31 yrs	13,000 to 612,000 up to 7,000,000 in lg females	53.0 cm	21.8 cm F 21.9 cm M	BS	3.5 + 0.53	Low	High	High	High	Source: Norris <i>et al.</i> 2002 Smallwood <i>et al.</i> 2013 www.fishbase.org Notes: True estuarine species
Whiting, other	2 yrs	12 yrs	170,000 - 217,000	41.4 cm	20 cm M/F	BS	3.2 + 0.2	Low	High	High	High	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org Notes: Based on yellowfin whiting (<i>Sillago schomburgkii</i>)
Flathead, other	1-2 yrs	12 yrs	-	90.0 cm	25-40 cm F 19-31 cm M	BS	4.0 + 0.4	Low	High	High	High	Based on Southern blue spotted flathead (<i>Platycephalus speculator</i>) Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
² Sea garfish (<i>Hyporhamphus melanochir</i>)	2-3 yrs	10 yr	10,000 2 seasonal peaks pr yr	52 cm	25 cm	BS	2.7 + 0.27	Low	High	High	High	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Leatherjacket	<5 yr	10-20 yr	>20,000	51 cm	<40 cm	BS	2.7 + 0.2	Low	High	High	High	Based on horseshoe leatherjacket (<i>Meuschenia hippocrepis</i>) Source: www.fishbase.org

Table 4 (cont.). Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for sea mullet in the Peel-Harvey Estuary.

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Octopus (<i>Octopus tetricus</i>)	0.5 yr	1-2 yr	125,000-700,000	-	100-50 g M 1000-2000 g F	DEL	Med	Low	Med	Med	Med	Joll 1983 Wadley and Dunning 1998
Pilchard	1-3 yrs	8 yrs	10,000 – 45,000	20.0 cm	12.0 cm	BS	2.4 + 0.1	Low	High	Low	High	Based on <i>Sardinops sagax</i> Source: www.fishbase.org DoF 1996 Notes: Selectivity is rated as low due to small size and ability to pass through gill nets
WA salmon (<i>Arripis truttaceus</i>)	3-5 yrs	9 yrs	-	96.1 cm	60-65 cm	BS	4.4 + 0.75	Low	High	High	High	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Yellowtail scad (<i>Trachurus novaezelandiae</i>)	3-4 yrs	28 yr	-	33.3 cm	26-30 cm	BS	3.2 + 0.4	Low	High	High	High	Source: www.fishbase.org www.dpi.nsw.gov.au/data/assets/pdf_file/0004/37597/0/Yellowtail-Scad.pdf Steer <i>et al.</i> 2004
Skates and rays, other	<5	10-20	2-5 eggs	146 cm	89 cm	LB		Low	Med	Med	Med	Based on Southern fiddler ray (<i>Trygonorrhina dumerilii</i>) Source: Last and Stevens 2009
Squid	<1 yr	1 yr	200 Multiple batches	50 Cm M 40 cm F	15-20 cm	DEL		Low	Med	Med	Med	Based on Southern calamari (<i>Sepioteuthis australis</i>) Source: Moltschaniwskyj and Steer 2004 http://www.dpi.nsw.gov.au/data/assets/pdf_file/0006/375945/Southern-Calamari.pdf
Trumpeters/Grunters	2 yr	10 yr	-	28 cm	13.1 cm F 14.0 cm M	BS	3.0 + 0.4	Low	High	High	High	Based on Western striped trumpeter (<i>Pelates octolineatus</i>) Source: www.fishbase.org Veale (2013)
Mulloway (<i>Argyrosomus japonicas</i>)	6 yr	40 yrs	900,000 to 1,000,000,	200 cm	90.3 cm F 87.3 cm M	BS	4.5 + 0.6	Low	High	High	High	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org

Table 4 (cont.). Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for sea mullet in the Peel-Harvey Estuary.

Species/Group	Productivity							Susceptibility				Comments
	Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner DEL - demersal egg layer LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Giant herring	< 5 yr	10-20 yr	>20,000	118 cm	<40 cm	BS	4.0 + 0.3	Low	High	High	High	Based on <i>Elops machnata</i> Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Flounders	< 5yrs	10-20 yr	>20,000	34 cm	<40 cm	BS	3.5 + 0.37	Low	Med	Med	Med	Based on <i>Pseudorhombus jenynsii</i> (commonly caught in the West Coast Bioregion)
Bycatch species												
Little bycatch in the fishery, based on bycatch in commercial crab traps in the Peel-Harvey Estuary												
Weeping toadfish (<i>Torquigener pleurogramma</i>)	1 yr	6 yr	17,000-207,000	23.0 cm	-	DEL	3.3 + 0.5	Low	High	Med	Med	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Trumpeters / Grunters	2 yr	10 yr	-	28 cm	13.1 cm F 14.0 cm M	BS	3.0 + 0.4	Low	High	High	High	Based on Western striped trumpeter (<i>Pelates octolineatus</i>) Source: www.fishbase.org Veale 2013
Blue swimmer crabs (<i>Portunus armatus</i>)	< 1 yr	1.8 yr	68,450 to 324,440	20.0 cm	8.6 - 9.8 cm M/F	BS		Med	High	High	Low	de Lestang 2002 de Lestang <i>et al.</i> 2003 a, b, c
Jellyfish	< 5yr	< 10 yr	>20,000	<100	<40	BS		Low	High	Med	High	
ETP species												
Syngnathids (<i>Hippocampus</i> spp.)	< 5 years	< 5 years	Small brood size (< 100 offspring per year)	~ 20 – 30 cm	~ 10 cm	LB		High	Med	Med	Med	EPBC Listing: 23 species listed as marine IUCN Listing: Data deficient to vulnerable CITES Listing: None Source: Exmouth Gulf and Shark Bay Prawn Fishery PSAs Notes: Relatively low population densities, with strong habitat association (generally found around edges of seagrass beds and macroalgae-dominated reefs); low natural rates of mortality.

¹ Indicator species for estuarine finfish suite in West Coast Bioregion

² Indicator species for nearshore finfish suite for West Coast Bioregion

Table 5. PSA scores for target, non-target retained, bycatch and ETPs, with the overall risk rating and MSC scoring guidepost.

Category	Scientific name	Common name	Gear type	Productivity Scores [1-3]							Total Productivity (average)	Susceptibility Scores [1-3]				Total (multiplicative)	PSA Scores (automatic)			MSC scoring guidepost
				Average age at maturity	Average max age	Fecundity	Average max size	Average size at Maturity	Reproductive strategy	Trophic level (fishbase)		Availability	Counterability	Selectivity	Post-capture mortality		PSA Score	MSC Score	Risk category name	
Target	<i>Mugil cephalus</i>	Sea mullet	Set/haul net	1	2	1	1	1	1	1	1.14	1	3	3	3	1.65	2.01	94.8	Low	>80
Retained	<i>Aldrichetta forsteri</i>	Yelloweye mullet	Set/haul net	1	1	1	1	1	1	1	1.00	1	3	3	3	1.65	1.93	96.0	Low	>80
Retained	<i>Sillago schomburgkii</i>	Yellowfin whiting	Set/haul net	1	2	1	1	1	1	3	1.43	1	3	3	3	1.65	2.18	91.7	Low	>80
Retained	<i>Pomatomus saltatrix</i>	Tailor	Set/haul net	1	2	1	2	2	1	3	1.71	1	3	3	3	1.65	2.38	87.3	Low	>80
Retained	<i>Cnidoglanis macrocephalus</i>	Cobbler	Set/haul net	1	2	2	1	2	2	2	1.71	3	3	2	3	2.33	2.89	71.7	Med	60-80
Retained	<i>Arripis georgianus</i>	Australian herring	Set/haul net	1	2	1	1	1	1	3	1.43	1	3	3	3	1.65	2.18	91.7	Low	>80
Retained	<i>Pseudocaranx georgianus</i>	Trevally, Silver, Skipjack	Set/haul net	1	2	1	1	1	1	3	1.43	1	3	3	3	1.65	2.18	91.7	Low	>80
Retained	<i>Nematalosa vlaminghi</i>	Perth herring	Set/haul net	1	2	1	1	1	1	3	1.43	2	3	3	3	2.33	2.73	77.2	Med	60-80
Retained	<i>Sillaginodes punctata</i>	King George whiting	Set/haul net	1	2	1	1	2	1	3	1.57	1	3	3	3	1.65	2.28	89.7	Low	>80
Retained	<i>Acanthopagrus butcheri</i>	Black bream	Set/haul net	1	3	1	1	1	1	3	1.57	1	3	3	3	1.65	2.28	89.7	Low	>80
Retained	<i>Platycephalus speculator</i>	Flathead	Set/haul net	1	2	1	1	1	1	3	1.43	1	3	3	3	1.65	1.65	98.9	Low	>80
Retained	<i>Hyporhamphus melanochir</i>	Sea garfish	Set/haul net	1	2	1	2	1	1	1	1.29	1	3	3	3	1.65	2.09	93.4	Low	>80
Retained	<i>Meuschenia hippocrepis</i>	Leatherjacket	Set/haul net	1	2	1	1	1	1	2	1.29	1	3	3	3	1.65	2.09	93.4	Low	>80
Retained	<i>Octopus tetricus</i>	Octopus	Set/haul net	1	1	1	1	1	2	2	1.29	1	2	2	2	1.18	1.74	98.2	Low	>80
Retained	<i>Sardinops sagax</i>	Pilchard	Set/haul net	1	1	2	1	1	1	1	1.14	1	3	1	3	1.20	1.66	98.9	Low	>80
Retained	<i>Arripis truttaceus</i>	WA salmon	Set/haul net	1	1	1	1	2	1	3	1.43	1	3	3	3	1.65	2.18	91.7	Low	>80
Retained	<i>Trachurus novaezelandiae</i>	Yellowtail scad	Set/haul net	1	3	1	1	1	1	2	1.43	1	3	3	3	1.65	2.18	91.7	Low	>80
Retained	Skates and Rays	Skates and rays	Set/haul net	1	2	3	2	2	3	2	2.14	1	2	2	2	1.18	2.44	85.7	Low	>80
Retained	Squid	Squid	Set/haul net	1	1	2	1	1	2	2	1.43	1	2	2	2	1.18	1.85	97.0	Low	>80
Retained	<i>Argyrosomus japonica</i>	Mulloway	Set/haul net	2	3	1	2	2	1	3	2.00	1	3	3	3	1.65	2.59	81.5	Low	>80
Retained	<i>Elops machnata</i>	Giant herring	Set/haul net	1	2	1	2	1	1	3	1.57	1	3	3	3	1.65	2.28	89.7	Low	>80
Retained	<i>Pseudorhombus jenynsii</i>	Flounders	Set/haul net	1	2	1	1	1	1	3	1.43	1	3	3	3	1.65	2.18	91.7	Low	>80
Retained/ Bycatch	Trumpters/Grunters	Trumpters/Grunters	Set/haul net	1	1	1	1	1	1	2	1.14	1	3	3	3	1.65	2.01	94.8	Low	>80
Retained	<i>Hyperlophus vittatus</i>	Whitebait	Set/haul net	1	1	1	1	1	1	3	1.29	1	3	1	3	1.20	1.76	98.0	Low	>80
Bycatch	<i>Torquigener pleurogramma</i>	Blowfish or toadfish	Set/haul net	1	1	1	1	1	1	3	1.29	1	3	2	2	1.28	1.81	97.5	Low	>80
Bycatch	Jellyfish	Jellyfish	Set/haul net	1	1	1	1	1	1	1	1.00	1	3	2	1	1.13	1.51	99.7	Low	>80

Bycatch	<i>Portunus armatus</i>	Blue swimmer crabs	Set/haul net	1	1	1	1	1	1	2	1.14	2	3	3	1	1.43	1.83	97.3	Low	>80
ETP	<i>Hippocampus spp.</i>	Syngnathids	Set/haul net	1	1	3	1	1	3	2	1.71	1	2	2	2	1.18	2.08	93.7	Low	>80

References

- Brown, J., Dowling, C., Hesp, A., Smith, K., and Molony, B. 2013. Status of nearshore finfish stocks in southwestern Western Australia. Part 3: Whiting (*Sillaginidae*). Fisheries Research Report No. 248. Department of Fisheries, WA, 128 pp.
- Chubb, C. and Potter, I. 1986. Age, growth and condition of the Perth herring *Nematolosa vlaminghi* (Munro) (Dorosomatinae) in the Swan Estuary, south-western Australia. *Australian Journal of Marine and Freshwater Research* 37: 105-112
- Chubb, C. F., and Potter, I. C. (1984). The reproductive biology and estuarine movements of the gizzard shad, *Nematolosa vlaminghi* (Munro). *Journal of Fish Biology* 25: 527-43.
- Chubb, C.F., Potter, I.C., Grant, C.J., Lenanton, R.C.J. & Wallace, J.H. (1981). Age structure, growth rates and movements of sea mullet, *Mugil cephalus* L., and yellow eye mullet, *Aldrichetta forsteri* (Valenciennes), in the Swan-Avon River System, Western Australia. *Australian Journal of Marine and Freshwater Research* 32: 605-628.
- Chuwen, B.M., Potter, I.C., Hall, N.G, Hoeksema, S., Laurenson, L.B. (2011). Changes in catch rates and length and age at maturity, but not growth, of an estuarine plotosid (*Cnidoglanis macrocephalus*) after heavy fishing. *Fishery Bulletin* 109: 247-260.
- de Lestang, S. (2002). Biology of the blue swimmer crab, *Portunus pelagicus* (Linnaeus), in Western Australia. PhD thesis. Murdoch University, WA, 173 pp.
- de Lestang, S., Hall, N. & Potter, I.C. (2003b). Changes in density, age composition and growth rate of *Portunus pelagicus* in a large embayment in which fishing pressures and environmental conditions have been altered. *Journal of Crustacean Biology* 23(4): 908-919.
- de Lestang, S., Hall, N.G. & Potter, I.C. (2003a). Reproductive biology of the blue swimmer crab, *Portunus pelagicus* (Decapoda: Portunidae) in five water bodies on the west coast of Australia. *Fishery Bulletin* 101: 745-757.
- de Lestang, S., Hall, N.G. & Potter, I.C. (2003c). Do the age compositions and growth of the crab *Portunus pelagicus* in marine embayments and estuaries differ? *Journal of the Marine Biological Association of the United Kingdom* 83: 971-978.
- DoF. (1996). Management of the South Coast Purse Seine Fishery. Fisheries Management Paper No. 99. Department of Fisheries WA.
- Gaughan, D.J., Ayvazian, S., Nowara, G., Craine, M. & Brown, J. (2006). The development of a rigorous sampling program for a long term annual index of recruitment for finfish species from south-western Australia. Report to the FRDC on Project No. 1999/153, Fisheries Research Report No. 154. Department of Fisheries, WA, 135 pp.
- Hutchins, B. & Swainston, R. (1999). Sea fishes of southern Australia, 2nd edition. Swainston Publishing, New South Wales, Australia, 180 pp.
- Hyndes, G.A., Potter, I.C. & Hesp, S.A. (1996b). Relationships between the movements, growth, age structures, and reproductive biology of the teleosts *Sillago burrus* and *S. vittata* in temperate marine waters. *Marine Biology* 126: 549-558.

- Joll, L. M. (1983). “*Octopus tetricus*” In Cephalopod life cycles. edited by P.R. Boyle, vol. 1, New York : Academic Press, 2 v., p. 325-334.
- Last, P. R. & Stevens, J. D. (2009). Sharks and rays of Australia. CSIRO Publishing, Victoria, Australia.
- Moltschaniwskyj, N.A. & Steer, M.A. (2004). Spatial and seasonal variation in reproductive characteristics and spawning of southern calamary (*Sepioteuthis australis*): spreading the mortality risk. *ICES Journal of Marine Science* 61: 921- 927.
- Nel, S.A., Potter, I.C. & Loneragan, N.R. (1985). The Biology of the Catfish *Cnidoglanis macrocephalus* (Plotosidae) in an Australian Estuary. *Estuarine, Coastal and Shelf Science* 21: 895-909.
- Norriss, J.V., Tregonning, F.E., Lenanton, R.C.J., Sarree, G.A. 2001. Biological synopsis of the black bream, *Acanthopagrus butcheri* (Munro) (Teleostei: Sparidae) in Western Australia with reference to information from other southern states. Fisheries Research Report No. 93. Department of Fisheries, WA. 128 pp.
- Smallwood, C.B., Hesp, A., Beckley, L.B. (2013) Biology, stock status and management summaries for selected fish species in south-western Australia. Fisheries Research Report No. 242. Department of Fisheries, WA. 171pp.
- Smith, K. and Brown, J. 2014. Biological synopsis of Australian herring (*Arripis georgianus*). Fisheries Research Report No. 251. Department of Fisheries, WA, 128 pp.
- Smith, K.A. & Deguara, K. (2002). Review of biological information and stock assessment for the NSW sea mullet resource. New South Wales Fisheries Resource Assessment Series No. 12. New South Wales Fisheries, Cronulla, Australia, 23 pp.
- Steer, M.A., Moltschaniwskyj, N.A., Nichols, D.S. & Miller, M. (2004) The role of temperature and maternal ration in embryo survival: using the dumpling squid *Euprymna tasmanica* as a model. *Journal of Experimental Marine Biology and Ecology* 307: 73– 89.
- Veale, L.J. (2013). Inter-period comparisons of the ichthyofaunas of two nearby, modified estuaries and the biology of *Pelates octolineatus* (Terapontidae). PhD Thesis. Murdoch University, 285 pp.
- Wadley, V. A. & Dunning, M. (1998). Cephalopods of commercial importance in Australian fisheries. CSIRO, Marine Research.

Commercial Trap and Recreational Drop and Scoop Net Fishery in the PHE

Introduction and Methods

In the Peel-Harvey Estuary, blue swimmer crabs are fished as a part of the commercial WCEMF Area 2 using crab traps, and the Peel-Harvey Estuary Blue Swimmer Crab Recreational Fishery using drop and scoop nets. There are management procedures in place to assess and mitigate the potential impacts of both commercial and recreational fishing on target, non-target retained, by catch and ETPs. These include ecological risk assessments (ERA), spatial closures, temporal and seasonal closures, limited entry (commercial only), effort controls (commercial only), gear restrictions and compulsory reporting (commercial only).

To assess the risk to all target, retained and bycatch species within the commercial and recreational fisheries for blue swimmer crabs in the Peel-Harvey Estuary, a PSA assessment was conducted. Tables 6-8 document retained species and Tables 9-11 identify bycatch species for each of the different gear types (trap, drop net and scoop net) based on commercial fishers catch and effort returns and recreational survey data.

Information for productivity scores was obtained from the same sources as described above for the commercial net fishery in the Peel-Harvey Estuary. Where productivity attributes for a particular species were not available values for a similar species (in the same family) were used. If no productivity scores were available a precautionary approach was used and species were assigned the most conservative score. In some cases, where species identifications were uncertain similar species were grouped together. In these cases, the most conservative score was applied across the group i.e. skates.

A summary of the information used to justify the productivity and selectivity scores is provided in Table 12.

Results

The results from the PSA with the individual scores for each attribute and a total PSA score and risk rating is provided in Table 13. Note that the susceptibility scores differ based on the gear type used (commercial trap, recreational drop and scoop nets) and the PSA is scored accordingly. No species was scored above low risk (MSC score >80).

Table 6. All retained species (tonnes) for the Peel-Harvey Estuary commercial (trap) Fishery 2003/04 – 2012/13. Dark blue indicates target (P1) species. No primary species have been identified in this fishery.

Species	Catch (tonnes)									
	03/04	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13
Blue swimmer crab	57.75	78.67	72.38	103.69	90.19	48.20	63.91	62.08	81.19	102.36
Octopus	0.00	0.00	0.008	0.104	0.061	0.014	0.043	0.032	0.018	0.008
Total	57.75	78.67	72.39	103.80	90.25	48.22	63.95	62.12	81.21	102.36

Table 7. Total retained species (number) by recreational blue swimmer crab fishers using drop nets in 1998 – 1999 and 2007 – 2008 based on recreational survey data. Blue shading indicates target (P1) species

Species	Number Retained			
	1998	1999	2007	2008
Blue swimmer crab	5313	15829	866	7780
Australian Herring	1	69	0	49
Tailor	0	10	5	13
General/Sand Whiting	0	11	0	1
King George Whiting	0	6	0	4
School Southern / Silver Whiting	0	0	1	0
Western School Whiting	0	1	0	0
Western Rock Lobster	0	0	4	0
Skipjack/Silver Trevally	0	0	1	0
Six Lined Trumpeter (Striped Trumpeter)	0	0	0	2
Common blowfish	12	0	0	0
Mussels	18	30	0	0
Western Buffalo Bream	1	0	0	0
Octopus, general	0	1	0	0
Trumpeters/Grunters, general	0	2	0	0
Brown-Spotted Wrasse	0	1	0	0

Table 8. Total retained species (number) by recreational blue swimmer crab fishers using scoop nets in 1998 – 1999 and 2007 – 2008 based on recreational survey data. Blue shading indicates target (P1) species

Species	Number Retained			
	1998	1999	2007	2008
Blue Swimmer Crab	304	696	24	959
Australian Herring	0	26	0	45
Tailor	0	0	1	0
Mussels	18	0	0	0

Table 9. Bycatch species and catch observed in the Peel-Harvey Estuary (trap) fishery for blue swimmer crabs during on-board catch commercial monitoring conducted between July 2007 and December 2013. *Total number is an estimate for the entire period (2007 – 2013) based on observed catches per trap.

Common name	Species name	*Total Number	Total Number Per Trap
Weeping toadfish (common blowfish)	<i>Torquigener pleurogramma</i>	500	0 to 15
Western striped grunter (trumpeter)	<i>Pelates octolineatus</i>	<10	0 to 3
Common Sydney octopus, Gloomy octopus	<i>Octopus tetricus</i>	1	1 only
Cobbler	<i>Cnidoglanis macrocephalus</i>	1	1 only
Four-lobed swimming crab	<i>Thalamita sima</i>	<50	0 to 3
Mud crab	<i>Scylla</i> sp.	2	2 only

Table 10. Species discarded by recreational blue swimmer crab fishers using drop nets in 1998 – 1999 and 2007 – 2008 survey periods. Blue shading indicates target (P1) species.

Species	Number Discarded			
	1998	1999	2007	2008
Blue Swimmer Crab	6474	19288	2417	9676
Common Blowfish	1	9	0	11
Australian Herring	0	14	0	2
Rough Leatherjacket	2	0	0	3
Pufferfishes, Toadfishes And Tobies	0	0	5	0
Stingrays, general	0	0	0	1
Tailor	0	5	10	27
General/Sand Whiting	0	0	0	5
Western Sand Whiting	7	0	0	0
Wrasse/Groper, general	0	0	0	5

Table 11. Species discarded by recreational blue swimmer crab fishers using scoop nets in 1998 – 1999 and 2007 – 2008 survey periods. Blue shading indicates target (P1) species.

Species	Number Discarded			
	1998	1999	2007	2008
Blue Swimmer Crab	371	627	290	1243
Common Blowfish	0	0	0	34

Table 12. Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for blue swimmer crab in the Peel-Harvey Estuary for commercial traps, recreational drop and scoop nets. Note that the commercial trap fishery the only byproduct species is octopus, all other retained species relate to recreational fisheries.

Unit	Species/Group	Productivity							Susceptibility				Comments	
		Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner, DEL - demersal egg layer, LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality		
	Retained species													
Trap, Drop net, Scoop net	Blue swimmer crabs (<i>Portunus armatus</i>)	< 1 yr	20 mths	68,450 to 324,440	20.0 cm	Variable with location 86.2-97.5 mm M 86.9-98 mm F	BS		Low (PHE scoop net, WS & HI trap), Med (PHE trap, drop net), High (MB trap)	High	Med (all excl. PH scoop net), High (PH scoop net)	Med	Source: Kangas de Lestang 2002 de Lestang <i>et al.</i> 2003 a, b, c	
Trap, Drop net	Octopus (<i>Octopus tetricus</i>)	0.5 yr	1-2 yr	125,000-700,000	-	100-50 g M 1000-2000 g F	DEL		Low	High	Med	Med	Joll 1983 Wadley and Dunning 1998	
Drop net, Scoop net	² Australian herring (<i>Arripis georgianus</i>)	1.8 yrs M 2.2 yrs F	12 yrs	32,000 - 207,000	41 cm	17.4 cm M 19.4 cm F	BS	4.3 ± 0.6	Low	Low	Med	Med	Source: Smith and Brown 2014 Smallwood <i>et al.</i> 2013 www.fishbase.org	
Drop net, Scoop net	² Tailor (<i>Pomatomus saltatrix</i>)	2 yr	10 yrs	600,000 to 2,000,000	130 cm	35-45 cm M/F	BS	4.5 ± 0.3	Low	Low	Med	Med	Source: www.fishbase.org/ www.sms.si.edu/irlspec/pomatom_saltat.htm Smallwood <i>et al.</i> 2013	
Drop net	Yellowfin whiting (<i>Sillago schomburgkii</i>)	2 yr	12 yrs	117,000 to 217,000	41.4 cm	20 cm M22.5 F	BS	3.2 ± 0.2	Low	Low	Med	Med	Source: Hyndes <i>et al</i> 1996 Brown <i>et al.</i> 2013 www.fishbase.org	
Drop net	King George whiting (<i>Sillaginodes punctata</i>)	3-5 yrs	14-17 yr	100,000-800,000	72.0 cm	43.7 cm M 41.0 cm F	BS	3.3 ± 0.3	Low	Low	Med	Med	Source: Brown <i>et al.</i> 2013 Smallwood <i>et al.</i> 2013 www.fishbase.org	
Drop net	Southern school / silver whiting (<i>Sillago bassensis</i>)	-	-	-	36.0	20.0 cm	BS	3.3 0.47	Low	Low	Med	Med	Source: Brown <i>et al.</i> 2013 Smallwood <i>et al.</i> 2013 www.fishbase.org	

Table 12 (cont.). Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for blue swimmer crab in the Peel-Harvey Estuary for commercial traps, recreational drop and scoop nets. Note that the commercial trap fishery the only byproduct species is octopus, all other retained species relate to recreational fisheries.

Unit	Species/Group	Productivity							Susceptibility				Comments
		Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS – broadcast spawner, DEL – demersal egg layer, LB – live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Drop net	Western rock lobster (<i>Panulirus cygnus</i>)	4.9-5.6 yrs 6-7 yrs cold waters	15 years	200, 000 to 1,200,000	20 cm	Variable with location 65.0-87.5 mm F	BS		Low	High	Med	Med	Source: Bellchambers <i>et al.</i> 2012 Phillips <i>et al.</i> 1980
Drop net	Trevally, other (skippy) (<i>Pseudocaranx georgianus</i>)	3 yrs	18 yrs	30,000 - 220,000	93.8 cm	28-37 cm M/F	BS	3.9 ± 0.6	Low	High	Med	Med	Source: www.fishbase.org Little other published information
Drop net	Trumpeters/Grunters	2 yr	10 yr	-	28 cm	14.0 cm M 13.1 cm F	BS	3.0 ± 0.4	Low	Low	Med	Med	Based on Western striped trumpeter (<i>Pelates octolineatus</i>) Source: www.fishbase.org Veale 2013
Drop net	Weeping toadfish (<i>Torquigener pleurogramma</i>)	1 yr	6 yr	Variable with size 17,000-207,000	23.0 cm	-	DEL	3.3 ± 0.5	Low	Low	Med	Med	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Drop net, Scoop net	Mussels	1-2 yr	< 5 yr	5 to 8 m	10 cm	-	BS		Low	Low	Med	High	Based on <i>Mytilus edulis</i> Source: DoF (2000)
Drop net	Western buffalo bream (<i>Kyphosus sydneyanus</i>)	-	-	-	80 cm	-	BS	2.0 ± 0.0	Low	Low	Med	High	Source: www.fishbase.org Little published information
Drop net	Brown-spotted wrasse (<i>Notolabrus parilus</i>)	3 yr	12 yr	-	38.5 cm	19.5 cm	BS	3.5 ± 0.6	Low	Low	Med	Med	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Bycatch													
Trap, Drop net, Scoop net	Weeping toadfish (<i>Torquigener pleurogramma</i>)	1 yr	6 yr	Variable with size 17,000-207,000	23.0 cm	-	DEL	3.3 ± 0.5	Low	Low	Med	Med	Source: Smallwood <i>et al.</i> 2013 www.fishbase.org
Trap	Trumpeters/Grunters	2 yr	10 yr	-	28 cm	14 cm M 13 cm F	BS	3.0± 0.4	Low	Low	Med	Med	Source: www.fishbase.org

Table 12 (cont.). Information on the biology and susceptibility of targeted, byproduct, bycatch and ETP species for blue swimmer crab in the Peel-Harvey Estuary for commercial traps, recreational drop and scoop nets. Note that the commercial trap fishery the only byproduct species is octopus, all other retained species relate to recreational fisheries.

Unit	Species/Group	Productivity							Susceptibility				Comments
		Average age at maturity	Average max age	Fecundity	Average max size	Average size at maturity	Reproductive strategy (BS - broadcast spawner, DEL - demersal egg layer, LB - live bearer)	Trophic level	Availability (Areal overlap)	Encounterability (Vertical overlap)	Selectivity	Post-capture mortality	
Trap	Four lobed swimming crab (<i>Thalamita sima</i>)	< 5 yrs	< 10 yr	>20,000	<100	<40	BS	2.75-3.25	Low	High	Med	Med	Little information available on this species. Recommend using information blue swimmer crab.
Trap	Mud crab (<i>Scylla</i> sp.)	1.6 – 2 yr	< 10 y	>20,000	15-30 m dep on species	9 – 11 cm	BS	2.75-3.25	Low	High	Med	Med	Source: http://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_mud_crab.pdf
Drop net	Leatherjacket (<i>Meuschenia hippocrepis</i>)	<5 yr	10-25 yr	>20,000	51 cm	<40 cm	BS	2.7 ± 0.2	Low	High	High	High	Based on horseshoe leatherjacket (<i>Meuschenia hippocrepis</i>) Source: www.fishbase.org
Drop net	Stingrays, general	<5	10-20	2-5	146 cm	89 cm	LB	Med	Low	Low	Med	Low	Based on Southern fiddler ray (<i>Trygonorrhina dumerilii</i>) Source: Last and Stevens 2009
ETP species													
Trap, Drop net	Syngnathids (<i>Hippocampus</i> spp.)	< 5 years	< 5 years	Small brood size (< 100 offspring per year)	~ 20-30 cm	~ 10 cm	LB			Low	Low	Low	EPBC Listing: 23 species listed as marine IUCN Listing: Data deficient to vulnerable CITES Listing: None Source: Exmouth Gulf and Shark Bay Prawn Fishery PSAs Notes: Relatively low population densities, with strong habitat association (generally found around edges of seagrass beds and macroalgae-dominated reefs); low natural rates of mortality.

¹ Indicator species for estuarine finfish suite in West Coast Bioregion

² Indicator species for nearshore finfish suite for West Coast Bioregion

PHE – Peel-Harvey Estuary, WS – Warnbro Sound, HI – Hardy Inlet, MB – Mandurah to Bunbury

Table 13. PSA scores for target, non-target retained, by catch and ETPs, with the overall risk rating and MSC scoring guidepost.

Category	SCIENTIFIC NAME	COMMON NAME	GEAR TYPE	Productivity Scores [1-3]							Total Productivity (average)	Susceptibility Scores [1-3]				Total (multiplicative)	PSA Scores			MSC scoring guidepost
				Average age at maturity	Average max age	Fecundity	Average max size	Average size at Maturity	Reproductive strategy	Trophic level (fishbase)		Availability	Encounterability	Selectivity	Post-capture mortality		PSA Score	MSC Score	Risk category name	
Target (CT)	<i>Portunus armatus</i>	Blue swimmer crabs	Trap	1	1	1	1	1	1	2	1.14	1-3*	3	2-3*	2	1.54	1.92	96.2	Low	>80
Target (RDN)	<i>Portunus armatus</i>	Blue swimmer crabs	Drop net	1	1	1	1	1	1	2	1.14	2	3	2	2	1.58	1.25	99.9	Low	>80
Target (RSN)	<i>Portunus armatus</i>	Blue swimmer crabs	Scoop net	1	1	1	1	1	1	2	1.14	1	3	3	2	1.43	1.23	99.9	Low	>80
Retained/Bycatch	<i>Octopus tetricus</i>	Octopus	Trap/Drop net	1	1	1	1	1	2	3	1.43	1	3	2	2	1.28	1.49	99.8	Low	>80
Retained	<i>Arripis georgianus</i>	Australian herring	Drop/ Scoop net	1	2	1	1	1	1	3	1.43	1	1	2	2	1.08	1.79	97.7	Low	>80
Retained/Bycatch	<i>Pomatomus saltatrix</i>	Tailor	Drop/ Scoop net	1	2	1	2	2	1	3	1.71	1	1	2	2	1.08	2.02	94.6	Low	>80
Retained/Bycatch	<i>Sillago schomburgkii</i>	Yellowfin whiting	Drop net	1	2	1	1	1	1	3	1.43	1	1	2	2	1.08	1.79	97.7	Low	>80
Retained	<i>Sillaginodes punctat</i>	King George whiting	Drop net	1	2	1	1	2	1	3	1.57	1	1	2	2	1.08	1.90	96.3	Low	>80
Retained	<i>Sillago bassensis</i>	School / Silver whiting	Drop net	1	1	1	1	1	1	3	1.29	1	1	2	2	1.08	1.68	98.8	Low	>80
Retained	<i>Panulirus cygnus</i>	Western rock lobster	Drop net	2	2	1	1	1	1	2	1.43	1	3	2	2	1.28	1.91	96.2	Low	>80
Retained	<i>Pseudocaranx georgianus</i>	Trevally, other (skippy)	Drop net	1	2	1	1	1	1	3	1.43	1	1	2	2	1.08	1.79	97.7	Low	>80
Retained/Bycatch	<i>Pelates octolieneatus</i>	Trumpeters/ Grunters	Trap/Drop net	1	1	1	1	1	1	2	1.14	1	1	2	2	1.08	1.57	99.5	Low	>80
Retained/Bycatch	<i>Torquigener pleurogramma</i>	Toadfish/blow fish	Trap/Drop net/ Scoop net	1	1	1	1	1	2	3	1.43	1	1	2	2	1.08	1.79	97.7	Low	>80
Retained	<i>Mytilus galloprovincialis</i>	Mussels	Drop/ Scoop net	1	1	1	1	1	1	1	1.00	1	1	1	2	1.03	1.43	99.9	Low	>80
Retained	<i>Kyphosus sydneyanus</i>	Western buffalo bream	Drop net	2	2	1	1	1	1	2	1.43	1	1	2	2	1.08	1.79	97.7	Low	>80
Retained/Bycatch	<i>Notolabrus parilus</i>	Brown-spotted wrasse	Drop net	1	2	1	1	1	1	3	1.43	1	1	2	2	1.08	1.79	97.7	Low	>80
Bycatch	<i>Cnidogobius macrocephalus</i>	Cobbler	Trap	1	2	2	1	2	2	2	1.71	1	1	2	1	1.03	2.00	95.0	Low	>80

Bycatch	<i>Thalamita sima</i>	Four lobed swimming crab	Trap	1	1	1	1	1	1	2	1.14	1	3	2	2	1.28	1.71	98.5	Low	>80
Bycatch	<i>Scylla sp.</i>	Mud crab	Trap	1	1	1	1	1	1	2	1.14	1	3	2	2	1.28	1.71	98.5	Low	>80
Bycatch	<i>Meuschenia hippocrepis</i>	Leatherjacket	Drop net	1	2	1	1	1	1	2	1.29	1	1	2	2	1.08	1.68	98.8	Low	>80
Bycatch	<i>Trygonorrhina dumerilii</i>	Stingrays general	Drop net	1	2	3	2	2	3	2	2.14	1	3	2	1	1.13	2.42	86.3	Low	>80
ETP	<i>Hippocampus spp.</i>	Syngnathids	Drop net	1	1	3	1	1	3	2	1.71	1	3	1	1	1.05	2.01	94.8	Low	>80

*Note that score is dependent on the fishery targeting stock (see Table 12 above).

References

- Brown, J., Dowling, C., Hesp, A., Smith, K. & Molony, B. (2013). Status of nearshore finfish stocks in southwestern Western Australia. Part 3: Whiting (*Sillaginidae*). Fisheries Research Report No. 248. Department of Fisheries, WA, 128 pp.
- de Lestang, S. (2002). Biology of the blue swimmer crab, *Portunus pelagicus* (Linnaeus), in Western Australia. PhD thesis. Murdoch University, WA, 173 pp.
- de Lestang, S., Hall, N. & Potter, I.C. (2003b). Changes in density, age composition and growth rate of *Portunus pelagicus* in a large embayment in which fishing pressures and environmental conditions have been altered. *Journal of Crustacean Biology* 23(4): 908-919.
- de Lestang, S., Hall, N.G. & Potter, I.C. (2003a). Reproductive biology of the blue swimmer crab, *Portunus pelagicus* (Decapoda: Portunidae) in five water bodies on the west coast of Australia. *Fishery Bulletin* 101: 745-757.
- de Lestang, S., Hall, N.G. & Potter, I.C. (2003c). Do the age compositions and growth of the crab *Portunus pelagicus* in marine embayments and estuaries differ? *Journal of the Marine Biological Association of the United Kingdom* 83: 971-978.
- Department of Fisheries [DoF]. (2000). Farming mussels. Aquaculture WA. Department of Fisheries, WA, 7 pp.
- Hyndes, G.A., Potter, I.C. and Hesp, S.A. (1996). Relationships between the movements, growth, age structures, and reproductive biology of the teleosts *Sillago burrus* and *S. vittata* in temperate marine waters. *Marine Biology* 126: 549-558.
- Joll, L. M. (1983). “*Octopus tetricus*” In Cephalopod life cycles. edited by P.R. Boyle, vol. 1, New York : Academic Press, 2 v., p. 325-334.
- Kangas, M. (2000). Synopsis of the biology and exploitation of the blue swimmer crab, *Portunus pelagicus* Linnaeus, in Western Australia. Fisheries Research Report No. 121. Department of Fisheries, WA, 25 pp.
- Smallwood, C.B., Hesp, A., Beckley, L.B. (2013) Biology, stock status and management summaries for selected fish species in south-western Australia. Fisheries Research Report No. 242. Department of Fisheries, WA, 171pp.
- Smith, K. and Brown, J. 2014. Biological synopsis of Australian herring (*Arripis georgianus*). Fisheries Research Report No. 251. Department of Fisheries, WA, 128 pp.

Scale Intensity Consequence Analysis (SICA) and Consequence Spatial Analysis (CSA)

For data-limited fisheries, there are two risk-based approaches to assessing impacts on habitats:

1. Scale Intensity Consequence Analysis (SICA) which considers the scale (temporal and spatial) intensity of fishery's activities on a range of scoring issues, and consequence for most vulnerable habitats. This is the current approach used in MSC Certification Requirements Version 1.3.
2. Consequence Spatial Analysis (CSA). The CSA is based on semi-quantitative information and uses a scoring spreadsheet. This is the new approach used in MSC Certification Requirements Version 2.0.

Commercial Net Fishery in the PHE

Introduction and Methods

The potential impacts of the WCEMF netting finfish fishery to benthic habitats in the PHE are currently unknown. There is limited information on benthic habitats and habitat mapping has only been done at a broad scale (i.e. macroalgal and seagrass biomass). There are three main benthic types in the PHE; sand, seagrass and macroalgae, with the latter being highly ephemeral and variable. The location of commercial netting activities relative to benthic habitats in the estuary are relatively unknown as all commercial fishing activities occur within one reporting block on the catch and effort returns submitted by commercial fishers.

Due to the lack of quantitative data, a SICA and a CSA were both undertaken to assess the risk of the fishery impacting on habitats in the Peel-Harvey Estuary. Each of the two fishing methods (haul and gillnet) were assessed separately in the SICA and CSA analyses.

For each method, a worst possible scenario was decided and the scoring template was completed using the SICA and CSA methodologies. Scoring was based on:

- Bathymetric mapping (see Figure 1.1); and
- Habitat information and mapping (Figure 9.2, Figure 9.3).

For the CSA, habitats in the Peel-Harvey Estuary were defined according to nomenclature in the MSC Certification Requirements Version 2.0 (Table 14).

Table 14. Definition of habitat characteristic of the Peel-Harvey Estuary.

Substratum	Geomorphology	Biota
Coarse sediments	Low relief	Flora – dominated by macroalgae and seagrass

Results

Using the SICA methodology, haul and gillnetting in the PHE scored a Consequence Category of 1, which has an MSC equivalent score of 100 % (Tables 15-16). Using the CSA methodology, both haul and gillnetting scored 70 %, i.e. medium risk (Table 17).

Table 15. SICA scoring for PI 2.4.1 Habitats in relation to impacts from haul nets used to capture sea mullet in the Peel-Harvey Estuary.

Performance Indicator	Risk-causing activities from fishery under assessment	Spatial scale of activity	Temporal scale of activity	Intensity of activities	Relevant subcomponents	Consequence score	MSC Score
Principle Two Habitats Outcome:	Fishing • Gear loss • Bait collection • Anchoring/mooring • Navigation and steaming	6	4	3	Habitat types		
Habitat					Habitat structure and function	1	100
Rationale for selecting worst plausible case scenario	Potential impacts from fishing activities were considered the worst case scenario. There is little gear loss in the fishery, vessels do not anchor, and all vessels are required to be <6.5m						
Rational for spatial scale of activity	Haul nets are used throughout the estuary						
Rationale for temporal scale of activity	The 2013 catch data showed an average of 117 days of operation per year using haul nets across all licensees.						
Rational for intensity of activity	There are a low number of licensed fishers (11) in the Peel-Harvey Estuary, which fish at a broad spatial scale but are unlikely to have a detectable impact. Most fishers only fish for a couple of hours per day and are unlikely to have an impact.						
Rational for choosing most vulnerable sub-component	Macroalgae and seagrass distributions are intermixed in the Peel-Harvey Estuary (Figure 9.2, Figure 9.3). Both habitats variable and macroalagae tends to be seasonal in cover. Impacts to structure and function were considered more important than potential effects to habitat type.						
Rationale for consequence score	Haul nets are lightly weighted at the base of the net and any impacts are likely to be extremely localised without causing a detectable change internal dynamics of a habitat or the species making up the habitat. There are a low number licensed fishermen operating in the estuary who fish for less than half the year (on average). A FRDC research project found no conclusive evidence of impacts of net hauling in NSW (Otway and Macbeth 1999).						

Table 16. SICA scoring for PI 2.4.1 Habitats in relation to impacts from gillnets used to capture sea mullet in the Peel-Harvey Estuary.

Performance Indicator	Risk-causing activities from fishery under assessment	Spatial scale of activity	Temporal scale of activity	Intensity of activities	Relevant subcomponents	Consequence score	MSC Score
Principle Two Habitats Outcome:	Fishing • Gear loss • Bait collection • Anchoring/mooring • Navigation and steaming	3	3	3	Habitat types		
Habitat					Habitat structure and function	1	100
Rationale for selecting worst plausible case scenario	Potential impacts from fishing activities were considered the worst case scenario. There is little gear loss in the fishery, vessels do not anchor, and all vessels are required to be <6.5m						
Rational for spatial scale of activity	Gill nets are only set in particular areas of the estuary – usually in deeper channel type areas, where there is greater fish movement.						
Rationale for temporal scale of activity	The 2013 catch data showed an average of 83 days fished per year across all licensees.						
Rational for intensity of activity	Gill nets are only set in certain parts of the estuary and commercial fishers operate on average less than a quarter of the year.						
Rational for choosing most vulnerable sub-component	Macroalgae and seagrass distributions are intermixed in the Peel Harvey (Figure 9.2, Figure 9.3). Both habitats variable and macroalagae tends to be seasonal in cover. Impacts to structure and function were considered more important than potential effects to habitat type.						
Rationale for consequence score	Gillnets are anchored at either end and any impacts are likely to be extremely localised without causing a detectable change internal dynamics of a habitat or the species making up the habitat. There are only a small number of licensees (11) of which only three used gillnets in 2013. These fishers only operated for approximately one quarter of the year, in restricted locations.						

Table 17. CSA scoring for PI 2.4.1 Habitats in relation to impacts from haul and gillnets used to capture sea mullet in the Peel-Harvey Estuary

Only main habitats scored?				Yes (sea grass)			Consequence score [1-3]								Spatial score [0.5-3]				CSA score	MSC CSA-derived score	Risk category	MSC scoring guidepost	
Habitat details							Habitat productivity		Gear-habitat interaction						Consequence score	Gear footprint	Spatial overlap	Encounterability					Spatial score
	UoA/ Gear type	Biome	Sub-biome	Feature	Habitat type	Depth (m)	Regeneration of biota	Natural disturbance	Removability of biota	Removability of substratum	Substratum hardness	Substratum ruggedness	Seabed slope										
	Gillnet	Coast	Coastal margin	Estuary	Seagrass	1.5	2	1	1	1	3	4	1	1.67	2	1.5	3	2.08	2.67	79	Med	60-79	
	Haulnet	Coast	Coastal margin	Estuary	Seagrass	1.5	2	1	1	1	3	5	1	1.67	2	2.5	3	2.47	2.98	68	Med	60-79	
																		MSC score	70				
																		Status	Pass with condition				

Commercial Trap and Recreational Drop and Scoop Net Fishery in the PHE

Introduction and Methods

The potential impacts of the WCEMF trap fishery and the PHE Blue Swimmer Crab Recreational Fishery (using drop and scoop nets) to benthic habitats in the PHE are currently unknown. There is limited information on benthic habitats in the Peel-Harvey Estuary, and mapping of habitats has only been done at a very broad scale (i.e. macroalgal and seagrass biomass). There are three main benthic types in the PHE; sand, seagrass and macroalgae, with the latter being highly ephemeral and variable. The approximate locations of commercial trapping activities relative to benthic habitats in the estuary is known from onboard commercial monitoring undertaken by Departmental Research staff. The approximate spatial extent of recreational blue swimmer crab fishing in the estuary has been inferred from anecdotal information provided by Fisheries and Marine Officers, and based on the depth of the estuary.

Due to the lack of quantitative data, a SICA and a CSA were both undertaken to assess the risk of the fisheries impacting benthic habitats in the PHE. Each of the three fishing methods (commercial trap and recreational drop and scoop net) were assessed separately in the SICA and CSA analyses.

For each method, a worst possible scenario was decided and the scoring template was completed using the SICA and CSA methodologies. Scoring was based on

- Bathymetric mapping (Figure 1.1);
- Habitat information and mapping (Figure 9.2, Figure 9.3);
- Commercial fishing activities (Figure 8.2); and
- Recreational fishing activities (Figure 9.5).

For the CSA, habitats in the PHE were defined according to nomenclature in the MSC Certification Requirements Version 2.0 (see Table 14 above).

Results

Using the SICA methodology, all three fishing methods scored a Consequence Category of 1, which has an MSC equivalent score of 100 % (Tables 18-20).

Using the CSA methodology, all methods scored > 80 %, i.e. low risk (Table 21).

Table 18. SICA scoring for PI 2.4.1 Habitats in relation to impacts from traps in the commercial blue swimmer crab fishery in the Peel-Harvey Estuary.

Performance Indicator	Risk-causing activities from fishery under assessment	Spatial scale of activity	Temporal scale of activity	Intensity of activities	Relevant subcomponents	Consequence score	MSC Score
Principle Two	<div><div>Fishing</div><div><ul style="list-style-type: none">• Gear loss• Bait collection• Anchoring/mooring• Other</div></div>	5	4	3	Habitat types		
Habitats Outcome:					Habitat structure and function	1	100
Habitat							
Rationale for selecting worst plausible case scenario	Potential impacts from fishing activities was considered the worst case scenario. There is little gear loss in the fishery, no bait collection, vessels do not anchor, and all vessel operations are in deeper water and therefore unlikely to disturb benthic habitats.						
Rational for spatial scale of activity	Commercial fishermen operate in deeper water in the Peel Harvey. It was estimated that the fishery operates over 46-60% of the estuary (Figure 8.2).						
Rationale for temporal scale of activity	CAES data was assessed across all 10 vessels in the fishery for 2013. The average number of days fished in 2013 was 167.						
Rational for intensity of activity	The fishery occurs across 45-60% of the estuary, operating on average 167 days per year. Detectable impacts are unlikely and if occurring likely to be localised.						
Rational for choosing most vulnerable sub-component	Macroalgae and seagrass distributions are intermixed in the Peel Harvey (Figures 9.2 & 9.3). Both habitats variable and macroalagae tends to be seasonal in cover. Impacts to structure and function were considered more important than potential effects to habitat type.						
Rationale for consequence score	Traps are unlikely to have any detectable change on the internal dynamics of a habitat or the populations of the species making up the habitat. Commercial traps are light with a wire rim and mesh frame, and are not weighted. The traps are set in shallow waters and unlikely to be dragged across the bottom during retrieval. Seagrass and macroalgae are flexible organisms and likely to bend under the weight of pots are highly ephemeral and variable in cover.						

Table 19. SICA scoring for PI 2.4.1 Habitats in relation to impacts from traps in the recreational blue swimmer crab (drop net) fishery in the Peel-Harvey Estuary.

Performance Indicator	Risk-causing activities from fishery under assessment	Spatial scale of activity	Temporal scale of activity	Intensity of activities	Relevant subcomponents	Consequence score	MSC Score
Principle Two Habitats Outcome:	<div>•Fishing</div> <div>•Gear loss</div> <div>•Bait collection</div> <div>•Anchoring/mooring</div> <div>Other</div>	6	4	3	Habitat types		
Habitat					<div>Habitat structure and function</div>	1	100
Rationale for selecting worst plausible case scenario	Potential impacts from fishing activities was considered the worst case scenario. There is little gear loss in the fishery, no bait collection, vessels do not anchor and most vessels are small i.e. <3m.						
Rational for spatial scale of activity	Recreational fishers utilise the majority of the estuary for drop netting (Figure 9.5)						
Rationale for temporal scale of activity	Recreational fishing only occurs for approximately half of the year i.e. <180 days						
Rational for intensity of activity	Recreational drop nets occur throughout the majority of the estuary. Any impacts are likely to be low and extremely localised.						
Rational for choosing most vulnerable sub-component	Macroalgae and seagrass distributions are intermixed in the Peel Harvey (Figures 9.2 & 9.3). Both habitats variable and macroalagae tends to be seasonal in cover. Impacts to structure and function were considered more important than potential effects to habitat type.						
Rationale for consequence score	Traps are unlikely to have any detectable change on the internal dynamics of a habitat or the populations of the species making up the habitat. Commercial traps are light with a wire rim and mesh frame, and are not weighted. The traps are set in shallow waters and unlikely to be dragged across the bottom during retrieval. Seagrass and macroalgae are flexible organisms and likely to bend under the weight of pots, are highly ephemeral and variable in cover.						

Table 20. SICA scoring for PI 2.4.1 Habitats in relation to impacts from traps in the recreational blue swimmer crab (scoop net) fishery in the Peel-Harvey Estuary.

Performance Indicator	Risk-causing activities from fishery under assessment	Spatial scale of activity	Temporal scale of activity	Intensity of activities	Relevant subcomponents	Consequence score	MSC Score
Principle Two Habitats Outcome:	<ul style="list-style-type: none"> •Fishing •Gear loss •Bait collection •Anchoring/mooring Other 	4	4	3	Habitat types		
Habitat					Habitat structure and function	1	100
Rationale for selecting worst plausible case scenario	Potential impacts from wading to scoop the crabs was considered the worst case scenario. The area of benthic habitat affected by wading was considered greater than the area in contact with scoop nets. There is little gear loss and no vessels involved in scoop netting.						
Rational for spatial scale of activity	Around 42% of the estuary is <0.8 m deep and considered to be available to wading scoop netters. This entire area is not exploited due to limited access points.						
Rationale for temporal scale of activity	Recreational fishing occurs for less than half of the year.						
Rational for intensity of activity	Certain parts of the estuary are more frequently utilised by scoop netters due to access points (roads and parking areas etc) (Figure 9.5). These areas are likely to have local detection. The majority of the estuary is not accessed as intensively and there are significant areas which are not visited by recreational fishers.						
Rational for choosing most vulnerable sub-component	Macroalgae and seagrass distributions are intermixed in the Peel Harvey (Figures 9.2 & 9.3). Both habitats variable and macroalagae tends to be seasonal in cover. Impacts to structure and function were considered more important than potential effects to habitat type.						
Rationale for consequence score	Wading is unlikely to have any detectable change on the internal dynamics of a habitat or the populations of the species making up the habitat. There are some localised areas where greater activity occurs, mainly around access points, but there are also large areas which are currently not utilised by scoop netters. Recreational fishing with scoop nets only occurs for around half of the year.						

Table 21. CSA scoring for PI 2.4.1 Habitats in relation to impacts from commercial traps and recreational drop and scoop nets used to capture blue swimmer crabs in the Peel-Harvey Estuary.

Only main habitats scored?				Yes (sea grass)				Consequence score [1-3]							Spatial score [0.5-3]				CSA score	MSC CSA-derived score	Risk category	MSC scoring guidepost
Habitat details							Habitat productivity		Gear-habitat interaction					Consequence score	Gear footprint	Spatial overlap	Encounterability	Spatial score				
	UoA/ Gear type	Biome	Sub-biome	Feature	Habitat type	Depth (m)	Regeneration of biota	Natural disturbance	Removability of biota	Removability of substratum	Substratum hardness	ruggedness	Seabed slope									
	Trap	Coast	Coastal margin	Estuary	Seagrass	2	2	1	1	1	3	3	1	1.67	1	2	3	1.82	2.47	85	Low	≥80
	Drop net	Coast	Coastal margin	Estuary	Seagrass	2	2	1	1	1	3	2	1	1.67	1	2.5	3	1.96	2.57	82	Low	≥80
	Scoop net	Coast	Coastal margin	Estuary	Seagrass	1	2	1	1	1	3	1	1	1.67	1	1.5	3	1.65	2.27	91	Low	≥80
																		MSC score	90			
																		Status	Unconditional Pass			

Appendix C – 2010 External Review of Blue Swimmer Crab Research

Review conducted by Dr Wayne Sumpton

Senior Fisheries Biologist, Department of Agriculture and Fisheries (formerly Department of Employment, Economic Development and Innovation), Queensland

The scope of this review was to provide feedback on material presented in a number of draft fisheries reports and a one-day workshop convened to review blue swimmer crab (*Portunus pelagicus*) (BSC) research in Cockburn Sound, Peel-Harvey Estuary and elsewhere (e.g. Swan River, Warnbro Sound). This review, and its level of detail, is not intended to provide a comprehensive assessment of all aspects of these reports and the discussions from the workshop. My comments are limited to those issues that were immediately obvious from reviewing the reports without any reanalysis or detailed examination of all aspects presented.

I have reviewed each of the three components of the research separately (e.g. Cockburn Sound Fishery, Peel-Harvey Fishery, Peel-Harvey recreational survey) and have concentrated most effort on the Cockburn Sound Fishery as this was the one that had most information and was the focus of most discussion at the workshop. It was also the fishery that, prior to the workshop, I was advised was the focus of the review.

The terms of reference originally asked for comments regarding the Cockburn Sound fishery under a prescribed set of headings. I have chosen to address comments under those headings but point out that many of the comments I have made under the “weaknesses” headings are more issues for consideration rather than inherent weaknesses in either the design, data or analyses.

The assessment of the recreational surveys in particular was limited to my views of material presented at the workshop and the limited analyses and data presented in the draft Peel-Harvey report. This report was obviously a very early draft and I acknowledge that a more detailed assessment of the design and more detailed analyses of the data and results that were not available in the early draft report may indeed identify issues that were not immediately obvious from the material I have reviewed.

COCKBURN SOUND FISHERY RESEARCH

SUMMARY OF KEY FINDINGS/RECOMMENDATIONS

Overview of project

The project in my opinion met all the objectives as stated in the report and provided invaluable information necessary for future management of the Cockburn Sound blue swimmer crab fishery. Most aspects of the biological background and monitoring systems were very well designed, researched and analysed. I did see some limitations in the stock-

recruitment-environment relationship and I felt that this component of the research required careful evaluation. There is scope to further refine some of the sampling strategies largely by reducing the temporal and spatial extent of some of the surveys and by refocussing some of the sampling.

The management decision rule framework (and the predictive model that underpinned it) was also well developed and provided sound management information, particularly as it has been developed in consultation with managers and they were prepared to use this information. The predictive power of the model that underpins the framework is of value in monitoring sustainability even if managers choose to manage this fishery without manipulating the length of the fishing season.

In any management system that promotes competitive behaviour among fishers, there is the incentive to fish harder in the knowledge that there is only a limited fishing season. If fishers know they have only a three month season, they will seek to maximise their returns. There is therefore incentive for fishers to use effort in excess of that to which they are entitled (e.g. more pots, etc.). This may not be an issue in this fishery but it has certainly occurred in other jurisdictions. Compliance with pot effort regulations can be difficult to monitor and enforce when fishers have the ability to set their gear over a very wide area such as Cockburn Sound.

I encourage the researchers to be vigilant in their use of effort measures and, in particular, those measures that are obtained from the monthly logbooks of fishers. Changes in catch rates can be blurred if logbook recording practises are not fully understood by those analysing the data or if management change alters fishers' behaviour and/or recording practises. This may not be an issue here but it is something that needs consideration as it has caused problems in similar fisheries where real declines in CPUE have not been picked up in logbook data. The assumption that logbook data are consistently and accurately recorded by fishers is often incorrect but sometimes there are also misunderstandings about how fishers are required to record their effort. There is also always the problem of false reporting, but there are mechanisms to validate logbooks (such as catch disposal records) and I assume these methods are in place in this fishery, or at least there is well founded confidence in the accuracy of logbook records. I acknowledge that the assessment relies predominantly on fisheries independent data and thus logbook records are not critical components of the decision framework

Research priorities

The previous research has provided a sound information base for managing this fishery. As the genetic information was inconclusive in the level of overlap among "stocks", it may be beneficial to collate information on the hydrodynamic environment, bathymetry and habitat type in the south western part of Western Australia as this would provide an indication of the likely mixing of stocks and the contribution made by areas close to each other.

I broadly support those research priorities identified in the report and note that the research trawl program for juvenile crabs is perhaps the most valuable. I also recognise that budgetary

constraints may reduce the capacity to continue with all the sampling currently undertaken. Detailed comments on each of the research objectives are contained within this report.

BIOLOGICAL BACKGROUND FOR STOCK(S)

Strengths

- Very comprehensive understanding of most aspects of the biology of BSC in the CS System. The research has provided a very sound biological basis for the management of the fishery.
- Well-designed research program with good sampling strategies and sample sizes.
- Spatial and temporal coverage is sound.

Weaknesses

- Lack of knowledge of the full extent of the potential fishery (waters outside of Cockburn Sound and Swan River).
- Uncertainty about the contribution that stocks outside CS may make to the CS fishery.
- Some uncertainty about the level of stock mixing from the genetic results.
- Lack of data regarding megalopal settlement.
- These are often far more important factors than egg production in determining future fishery production in similar crab fisheries.

MONITORING DATA SYSTEMS

Strengths

- Both fishery-dependent and fishery-independent methods have been used.
- The index of relative abundance of the 0+ and residual 1+ crabs appears to have good predictive power.
- Correlates well with predicted relative abundance.

Weaknesses

- The stock-recruitment relationship apparently uses information from all data sources but the researchers note that not all data are used in all months. There was insufficient information in the report to assess the validity of this method but, if the researchers have not already done so, they should use each of the data sources independently to produce the relationship and thereby assess any potential bias in one or other of the data sources.
- Use of two different vessels (Flinders and Naturaliste) to derive temporal indices. This may not be a problem if fishing gear and vessel fishing power were the same or at least standardised in the analysis. I assume this was the case.

- Use of environmental data from outside the system.

I also make the following points specifically about chapter 3 of the report, which the researchers may want to consider.

- Temperature records are taken **outside** the system in a manner that is pretty basic and possibly not representative of average temperature conditions during the months (2 samples).
- On a within year basis many biological parameters are correlated with temperature (Fig 3.1).
- There are clearly a few very influential points in some of the figures that are driving the derived relationships.
- The grouping of points into three distinct zones in fig 3.3 could represent the effects of management change as well as different vessels and sampling methods.

STOCK ASSESSMENTS

I felt that there was no stock assessment model presented in the report but I have addressed comments on stock status separately under other sections of this review that deal with the stock recruitment relationship and the fishery independent surveys that provide information on stock status.

MANAGEMENT DECISION-RULE FRAMEWORK

Strengths

- Decision rules appear to correlate well with predicted relative abundance of the stock. Data requirements are also not extreme as the framework is largely based on a relatively inexpensive research trawl survey.
- Researcher are also now in a position to review the temporal and spatial extent of the survey and can probably make efficiencies based on the outcomes of these analyses.

Weaknesses

- Requires ongoing commitment to review the status of stocks on an annual basis and to adjust catches accordingly.
- Uncertainty in the level of catch allocation to commercial fishers each year. This is probably not the ideal situation for industry but they would certainly view it as preferable to closure.
- Adjusting catches or effort each year requires increased management and compliance costs.
- Different management rules across geographic extent of the BSC stock may be overcomplicating management.

RESEARCH DIRECTIONS

Existing activities

The CS fishery has received extensive research coverage over the last three years thereby providing a sound basis for understanding some of the stock dynamics. The level of ongoing research and monitoring that should be apportioned to this fishery is a function of management needs and the management approach taken. The fact that this fishery has collapsed warrants extra caution when deciding on the level of ongoing monitoring. While comments on current management are outside the scope of this review, I make the point that a relatively conservative management regime has advantages in terms of costs. The more spatially- and temporally-complex the management regime, the greater are the costs of research and compliance to support that management.

I am inclined to agree with many of the suggestions for future research presented on page 99 of the draft report but, as is discussed elsewhere in this review, there is considerable scope for refining objectives and achieving cost savings (eg 3rd and 4th objectives can be refined by reducing the temporal scope of the sampling).

In reviewing the value of each of the three major field components (research 0+ surveys, Naturaliste surveys and commercial catch monitoring) as providing valuable data that would assist management, I felt that the research surveys were most important as they feed directly into the predictive relative abundance index. I anticipate that the contribution of residual 1+ component of the recruitment to the prediction of future relative abundance of the stock will not be as great once the stock is fished again and fishing mortality reduces the magnitude of this residual component in the surveys. The use of both the 0+ and 1+ components in the index provided a problem in the extent that each of these components should be weighted when deriving the overall index.

The 4th objective that dealt with the stock-recruitment/environment relationships I believe needs careful review as new data are available each year. I do not have the same level of confidence in the applicability of this relationship as I have in the catch prediction model based on juvenile sampling.

The refinement of the decision-making framework is only an important research option if management are to use the framework and advice in managing the CS fishery. The catch prediction model that underpins the framework is still a worthwhile monitoring tool.

The value and application of recreational surveys in the CS fishery really require high level cost-benefit analysis in my opinion, which is outside my brief. I make the point that most jurisdictions find that accurate and precise surveys of recreational catch are expensive to run and the objectives of the surveys need to be clearly defined and linked to some clear and specific need. One of the limiting factors in the CS system is that the recreational sector is also a small contributor (5-15%) to the overall catch (compared with the Peel Harvey system) and as such it may not be as critical to get regular estimates of recreational catch (particularly since total catch is not currently required in any stock assessment). I was, however, a bit

confused by catch sharing arrangements identified in the report (page 18) that pointed out a reallocation (increase to 37.5%) back to the recreational sector. If the catch share to the recreational sector increases then there will be an increased need for more information on catches by that sector.

The development of a population model is a debateable future research option in my opinion unless the outputs are required for ongoing management or are critical to some approved monitoring function. The current recruitment index is essentially fulfilling many of the monitoring requirements for this fishery as it is predicting future relative abundance. There is also the stock-recruitment relationship that has already been derived (although as I have stated elsewhere I don't feel that this relationship is as strong as highlighted in parts of the report). My understanding is that South Australia developed some sort of a population model for their BSC fishery some years ago. It may be beneficial to discuss model development with modellers in SA.

While I agree with investigating the value of tagging and migration studies in the Swan river, I advise caution due to the difficulty that many people have found with tag shedding on moulting and tag induced mortality in blue swimmer crabs. I would seriously reconsider this objective in the light of logistic and experimental difficulties.

New activities

While there is no doubt a relationship between egg production and temperature exists, I encourage the researchers to also think about the effect of other factors not only on egg production but also on settlement of megalopae and subsequent survival and relative abundance of 0+ juveniles. For many crab fisheries, wind stress, rainfall and other factors have had a dramatic impact on productivity. Even at relatively low levels of spawning stock and egg production, crab recruitment (particularly on such short lived and highly fecund species) is fairly independent of spawning stock biomass, and it is only at very low spawning stock biomass that recruitment failure occurs. This can obviously be dramatically impacted by unfavourable environmental conditions such as appears to have happened in the Cockburn Sound fishery.

Comments were made on the value of obtaining an estimate of catchability by undertaking depletion experiments. While this is a theoretically sound recommendation and has been successfully applied in many fisheries, I would advise caution as the logistics of running these experiments as well as the validity of some assumptions that underpin their application create problems in these types of fisheries. I am aware of several depletion experiments that have been undertaken (or at least attempted) on crabs elsewhere without success. Failure of these experiments is largely due to the migration of animals in and out of the experimental area as well as unpredictable short term changes of catchability due to behaviour.

PEEL HARVEY CRAB RESEARCH

In contrast to the Cockburn Sound fishery report there was not as much detail provided in the preliminary Peel-Harvey report and so I have limited my comments to a series of dot points that the researchers might want to consider in their ongoing review of the research in this system.

- The fact that this fishery has not suffered recruitment failure under current management measures does not ensure that it will not suffer failure (such as occurred in CS) in the future, however there are significant differences between the two systems which indicate lower risk (e.g. movement of females outside the estuary to spawn).
- Data sources in this fishery are limited to those obtained from pots, both in a fisheries-dependent and fisheries-independent context. I would advise a reassessment of the placing of the research pots and, in particular, the positioning of the pots outside the Dawesville Channel as these pots have not caught well and have provided little useful data.
- I was unable to understand fully the value of the beach seine data presented during the workshop and am thus unable to comment fully on its use in the context of understanding this fishery. I make the point that the fact that this sampling method is essentially limited to shallow shoreline areas limits its value in understanding the dynamics of a species that is distributed widely throughout the system. Seining will only be useful if it is adequately sampling the juvenile habitat.
- It may be possible to explore sampling outside the estuary using trawls or other non-potting methods.
- The collation of bottom type and hydrodynamic data would assist in determining whether habitat is suitable both for crabs and for other sampling methods such as trawling.
- Too few data have so far been collected to assess fully the recruitment index based on the catch of juveniles in modified pots. While catch rates in pots may not be a representative sample of the population in some circumstances, the fact that fishers in many similar fisheries have been able to successfully predict the success of future catches based on the bycatch of smaller undersized crabs that they see in their pots suggests that this method may be useful. I thus recommend that this method of predicting future relative abundance be continued until there are enough data to review whether it is a reasonable predictor.
- It would be beneficial to understand the temporal pattern of fishing in this estuary given the strong seasonal nature of the catch compositions with respect to sex ratio. Figure 10 of the report does show fishing effort concentrated towards the two openings to the system.

PEEL HARVEY RECREATIONAL SURVEYS

As noted in the preamble to this review, comments on the recreational surveys do not reflect an extensive analysis of the reports or in depth probe of methods. They merely reflect first impressions after discussions provided in the workshop and review of very early drafts of reports.

The vast majority of the catch in the Peel Harvey system is taken by the recreational sector (in contrast to Cockburn Sound) so there is a more pressing need for accurate estimates of recreational catch and effort in this system. If recreational surveys are to be conducted infrequently, it may be important to have an alternative independent means of monitoring and assessing the status of this fishery. Obviously this is an important budgetary question as the costs and benefits of different monitoring methods need to be compared.

The fact that the Peel Harvey surveys attempt to obtain estimates of recreational catch from, what appears to be, most of the fishing platforms is to be applauded as this is rarely done in these types of surveys due to logistic constraints. The studies do confirm that some of these platforms are only a minor component of the overall recreational catch with the majority of the catch and effort being from boat and scoop net fishers. Given the low contribution of some of these platforms to the total catch, it may be possible to restrict the sample frame by removing some of these platforms from the sampling. Houseboats in particular seems to contribute little to the overall catch and effort and cost saving could possibly be made by restricting the sample frame. These comments are of course predicated on an understanding that fishing from this platform is likely to continue to contribute little to the total catch and effort in the future.

I have read the methods sections for each of the three surveys undertaken and while I have not checked equations or calculations, I note that techniques appear to have followed protocols used throughout Australia and elsewhere. These techniques are accepted practises worldwide and, if applied with care and diligence in a well designed sampling program, should provide acceptable levels of accuracy and precision in estimated catch and effort parameters.

I note that the researchers have extensively reviewed these methods internally and have also sought the advice of external experts in developing their analytical techniques. I am aware that the methods used in an earlier survey were recently reviewed by an external consultant and the researchers have attempted to incorporate reviewer comments in the design and analysis of the most recent survey.

It was clear that some of the analytical techniques and stratification methods had little impact on the precision of the estimated parameters but there were specific analyses where the magnitude of the estimated parameters differed quite significantly among the various parameter calculation methods. I understand that one of the reasons these analyses were undertaken was to determine the influence that each method had on the point estimate and its variance, and thus bracket uncertainty. I am not in a position to provide specific advice to resolve which of the analytical methods (or combination of methods) would be preferable as

this would involve access to data and information than were not at my disposal. The fact that there were differences in the survey design (particularly related to temporal scope from some fishing platforms) between the two surveys means that, wherever possible, comparative analyses should be constrained to the same periods. It is clear that methods have been improved in the latter survey as a result of careful review of the earlier survey and, as such, later estimates are likely to be more accurate and precise (which is generally noticeable in the figures).

Overall, the levels of precision of estimated parameters are within acceptable limits expected in these types of surveys. The exception to this is the scoop netting release data (Figure 10) where uncertainty is quite high and the different analytical techniques provide very different parameter estimate trends across the two surveys. This is also the data set where the different analytical methods have the greatest impact on the magnitude of the estimates. I am not in a position to offer reasons for these discrepancies, but note that data and analyses used to generate this figure, in particular, need closer examination.

While I did not closely review the Voluntary Fisheries Liaison Officer (VLFO) report I am very aware of the structure and nature of these types of data and would advise caution in using them to infer catch rate trends. It is often tempting to use these data to back up trends that are apparent from other experimentally-controlled data sources such as stratified random surveys but I would advise caution in doing this as the lack of understanding about how and why these data are often collected can lead to biases and other problems. I do support the conclusions of this report, which note that data such as these may be useful in cases where there is some control over when and where the data are collected.

The catch from private homes along canals is an area that appears to be important as it is one which, as the report highlights, may be expanding. The two different analytical techniques underpinning the catch estimates from this fishing platform result in a four fold difference in estimated parameters. This is clearly an area that requires careful consideration as the assumptions of the first scenario, where non-diary participants were assumed not to have fished, is probably flawed. It is important to know whether diary participants are a random representative sample of fishers from this platform.

There are currently only two point estimates of recreational catch for this fishery, and the fact that the later survey estimate was lower than the first does not necessarily imply an overall declining trend in recreational catch or effort between the two periods. The result that recreational effort was lower in this system after nine years is an interesting and somewhat surprising result given comments about expanding recreational fishing pressure that were made during the workshop. Tighter bag limit restrictions imposed during the period between the two surveys was hypothesised as a reason for this decline but I have trouble accepting this given my observations of recreational fisher effort (in terms of time fishing) in other fisheries, which is often fairly independent of catch. Nevertheless, I acknowledge that scientists in WA are in a better position to assess this as there are often regional differences in fisher behaviour. I just make the point that, from my experience, it appears unusual.

Dr Wayne Sumpton, Queensland Department of Employment, Economic Development and Innovation, 5 October 2010

Monthly catch and effort return sheets completed by fishers in the WCEMF Area 2.

Notification of months when no fishing occurred is required on this form. A signed facsimile of this form may be submitted

Trap and line: catch and effort return

Fish Resources Management Regulations 1995: Regulation 64

Year	Month	Boat registration LFB	Boat name	
Fishing Boat Licence FBL		Managed fishery licence(s) MFL		
Anchorage		Master's CFL No.	Master's name	
Months you propose not to fish		Phone no.	Address	
No. days fished	Crew number (inc master)	Fuel purchased (litres)	I certify that the information on this form is correct. (Master, authorisation holder or agent)	Date signed

[illegible]

Dealer/processor		Crew names
Have you had an interaction with a protected species? Yes <input type="checkbox"/> No <input type="checkbox"/> If yes, was animal released Alive <input type="checkbox"/> Dead <input type="checkbox"/>	Species, location and other comments	

Notification of months when no fishing occurred is required on this form. A signed facsimile of this form may be submitted.

Appendix E – Waterbirds in the Peel-Harvey Estuary

Waterbird species present in the Peel-Harvey Estuary Ramsar site, along with listed species status and any breeding records within the site (Source: Hale & Butcher 2007)

Listed Status		Breeding Record
Ducks and Allies		
Australasian shoveler		
Australian shelduck		X
Australian wood duck		
Black swan		X
Blue-billed duck		
Chestnut teal		
Freckled duck		
Grey teal		X
Hardhead		
Musk duck	EPBC- Marine	
Pacific black duck		X
Pink-eared duck		
Grebes		
Australian grebe		
Great crested grebe		
Hoary-headed grebe		
Pelicans, cormorants, darters		
Australasian gannet	EPBC-Marine	
Australian pelican	EPBC-Marine	X
Darter		X
Great cormorant		
Little black cormorant		X
Little pied cormorant		X
Pied cormorant		
Herons, ibis, egrets and spoonbills		
Australian white ibis	EPBC- Marine	
Cattle egret	EPBC- Migratory, Marine, JAMBA, CAMBA	
Eastern reef egret	EPBC- Migratory, CAMBA, JAMBA	
Glossy ibis	EPBC- Migratory, CAMBA	
Great egret	EPBC- Migratory, CAMBA, JAMBA	
Little egret	EPBC- Marine	
Nankeen night heron	EPBC-Marine	
Royal spoonbill		

Straw-necked ibis EPBC-Marine

White-faced heron

White-necked heron

Yellow-billed spoonbill

Hawks, eagles and falcons

Osprey EPBC- Migratory, Marine

Swamp harrier EPBC- Marine

White-bellied sea eagle EPBC- Migratory, Marine, CAMBA

Crakes, rails, water hens, coots

Australian spotted crake

Baillon's crake EPBC-Marine

Black-tailed native hen

Buff-banded rail X

Dusky moorhen

Eurasian coot

Purple swamphen

Shorebirds

Banded lapwing

Banded stilt EPBC- Migratory

Bar-tailed godwit EPBC- Migratory, CAMBA, JAMBA, ROKAMBA

Black-fronted dotterel

Black-tailed godwit EPBC- Migratory, CAMBA, JAMBA, ROKAMBA

Black-winged stilt EPBC- Marine

Broad-billed sandpiper EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Common greenshank EPBC- Migratory, CAMBA, JAMBA

Common sandpiper EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Curlew sandpiper EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Eastern curlew EPBC- Migratory, CAMBA, JAMBA

Great knot EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Greater sand plover EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Grey plover EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Grey-tailed tattler EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Hooded plover EPBA- Marine

Inland dotterel

Lesser sand plover EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Long-toed stint EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Marsh sandpiper EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Pectoral sandpiper EPBC- Migratory, Marine, JAMBA, ROKAMBA

Pied oystercatcher

Red knot EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Red-capped plover	EPBC- Marine
Red-kneed dotterel	
Red-necked avocet	EPBC- Migratory
Red-necked stint	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA
Ruddy turnstone	EPBC- Migratory, CAMBA, JAMBA, ROKAMBA
Ruff	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA
Sanderling	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA
Sharp-tailed sandpiper	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA
Terek sandpiper	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA
Whimbrel	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA

Gulls, terns

Arctic tern	EPBC- Marine
Caspian tern	EPBC- Migratory, Marine, CAMBA, JAMBA
Common tern	EPBC- Migratory, Marine, CAMBA, JAMBA, ROKAMBA
Crested tern	EPBC- Marine
Fairy tern	EPBC- Marine
Gull-billed tern	EPBC- Marine
Roseate tern	EPBC- Marine, Migratory, JAMBA
Silver gull	EPBC- Marine
Whiskered tern	EPBC- Marine
White-winged tern	EPBC- Marine, Migratory, CAMBA, JAMBA, ROKAMBA

Appendix F – MLFA Code of Practice



CODE OF PRACTICE

Fresh, Local, Sustainable

West Coast Estuarine Fishery: Peel /Harvey Estuary



History of the Fishery

The West Coast Estuarine Fishery and more specifically the Peel/Harvey estuaries are one of the oldest fisheries in Australia, having existed since the first settlements of Mandurah and its surrounding districts were established. Many of the current operators in the fishery are 3rd and 4th generation fishermen, their great-grandfathers having established the fishery in the mid 1800's.

In the past the fishery supported upwards of 150 fishermen working in "family fishing units" supplying fish products to both local and metropolitan markets. Through licence consolidation and fisheries adjustment schemes the number of fishermen has been reduced down to 11 individual limited entry licenses. In 2003 the West Coast Estuarine Fishery (Interim) Management Plan saw the move away from the historic final eight family fishing units, with the fishermen issued 11 transferable interim permits.

Today commercial fishing is conducted by 11 small family businesses, targeting blue swimmer crab, estuarine fish and prawn species. The majority of the catch is edible quality fin fish and blue swimmer crabs which are delivered daily, fresh to local retailers. The shift away from targeting bulk hauls for the bait industry has resulted in overall lower annual catch returns. A smaller portion of our annual catch is delivered to the metropolitan bait wholesalers who in turn package this product for use by recreational fishers. Two families market the majority of their product through their own home retail outlets providing a fisherman direct supply chain to local consumers.

The fishery has moved away from targeting species in bulk, as niche markets for mainly edible product have seen the dollar value per kilo of fresh product rise. Fishermen are now able to selectively fish providing high quality edible product to local markets on a daily basis. The seafood harvested by the licensees is primarily consumed locally within Western Australia.

Code of Practice for Sustainable Fishing

Purpose of the Code of Practice

The Mandurah Licensed Fishermen's Association (MLFA), in conjunction with the Western Australian Fishing Industry Council and Department of Fisheries has developed this Code of Practice as a voluntary agreement between licensees of the West Coast Estuarine Fishery (Peel Harvey Estuary) to:

- Demonstrate the highest level of stewardship possible
- At all times act as environmental custodians
- Ensure the use of fishing practices that are environmentally sustainable
- Lead the way in community education by providing valuable information through our EMS on the estuary's ecosystem and environmental dynamics
- Aid in present and future research projects
- Comply with the Departmental Management Plan at all times whilst ensuring new entrants are practicing sustainable fishing methods within the regulations

Fresh, Local, Sustainable

West Coast Estuarine Fishery: Peel /Harvey Estuary



Vision Statement for the Mandurah Licensed Fishermen's Association

"To harvest seafood for the community in a manner that will ensure the continued supply of environmentally sustainable, commercially viable and universally respected product".

Operational Guidelines for Fishing Methodology and Vessel Operations

All licensees agree to abide by the following set of regulations in order to ensure the sustainability and longevity of the fishery.

Vessels are to be operated in such a way to minimize any environmental damage or disturbance to native wildlife.

Fishing pressure is to be spread evenly over a wide range of species to ensure that any one species is not over exploited.

Target volumes are to be kept within a range set by market demand.

Product quality is to be maintained at the highest possible standard.

Accurate catch records are to be maintained for Departmental use.

Continue to introduce proven environmental fishing methods such as the voluntary incorporation of escape gaps to crab traps and voluntary periodical size increases for identified species.

Provide aid in all research and environmental programs.

Refuelling operations are to be carried out on land where possible with spare fuel supplies being stowed in sealed appropriate containers.

Operators will report any observed environmental damage to the appropriate authorities.

Resource Sharing Outcomes 2010 - 2011

As part of the EMS process further consultation with Recreational Stakeholders was undertaken in a Resource Sharing Process which involved representatives from the MLFA, Recfishwest, WAFIC, and the Department of Fishers W.A. All fishermen are abiding by the following resolutions even though they have not to date been legislated owing to Departmental legalities.

A series of outcomes have been proposed and agreed upon and have been incorporated into our Code of Practice as voluntary measures that are followed by all members of the Association.

Fresh, Local, Sustainable



Voluntary Management Resolutions

In relation to cobbler, it was agreed that the West Coast Estuarine Fishery (Area 2):

- Reduce fishing for cobbler to three (3) nights per week during August. Those nights will be Monday, Wednesday and Friday.
- Half the amount of net that can be used in the water from 1000m to 500m.
- Increase minimum mesh size to 3 ½ inch (currently minimum mesh size of 3 inch).
- No bunting (a non-pocketed cobbler specific net) during from 1 August to 31 October.
- A Total Allowable Commercial Catch (TACC) limit of 10,000kg per year be put in place*
- *Monitoring and reviewing of the TACC would be the responsibility of the co-management group (put in place by the resource sharing group) noting the possibility of adjustment if there is evidence cobbler are becoming more abundant. The co-management group would also ensure that all the outcomes of the resource sharing agreement are achieved and maintained.

In relation to crabs, it was agreed that the West Coast Estuarine Fishery (Area 2):

- Increase the minimum size for female blue swimmers from 127mm to 130mm
- Incorporate escape gaps in all traps used within the fishery to ensure the release of juvenile crabs and reduce handling stress.

Emergency Response

All licensees agree to report any observed environmental incident including injured wildlife or pollution issues. Navigational hazards will also be reported to aid the relevant authorities in their expedient rectification.

Stakeholder Interactions

All licence holders will aim to conduct their fishing activities in a manner that will minimize conflict with other stakeholders. Operators will take reasonable measures to avoid fishing in areas already at use by other stakeholders, whilst aiming to leave minimal trace of fishing operations.

All operators will conduct fishing operations in a polite and professional manner ensuring any direct contact with other stakeholders is carried out in a similar manner. In the event of a user conflict arising, and mutual agreement unattainable, fishers will cease any further dialogue and refer the matter to the Secretary or President of the MLFA. The issue will then be resolved through consultation using WAFIC and Recfishwest representatives.

Fresh, Local, Sustainable

Western Australian Marine Stewardship Council Report Series No.3, 2015

261

Appendix H – Blue Swimmer Crab Published Article

Article published in the Chinese community Life Magazine about the crab fishing closure in the Peel-Harvey Estuary blue swimmer crab recreational fishery, September 2014.



9日1日至10月31日 政府關閉藍蟹捕撈區

文：西澳漁業局 編輯：李念慈

在西澳，藍蟹（Blue Swimmer Crab）是澳洲最珍貴的漁獲之一，是西澳人享受夏日生命的一部分。

為了保護藍蟹資源，西澳政府決定關閉藍蟹捕撈區。從9月1日至10月31日，政府將關閉藍蟹捕撈區，禁止在該地區進行商業捕撈。這項措施是為了保護藍蟹資源，確保其可持續利用。藍蟹的數量近年來有所下降，這主要是由於過度捕撈和環境因素的影響。政府希望通過關閉捕撈區，讓藍蟹資源得到充分的恢復和增長。

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Appendix I – Additional References Provided to Assessment Team

Principle 1

Caputi, N., Feng, M., Pearce, A., Benthuyssen, J., Denham, A., Hetzel, Y., Matear, R., Jackson, G., Molony, B., Joll, L. & Chandrapavan A. (2015). Management implications of climate change effect on fisheries in Western Australia, Part 1: Environmental change and risk assessment. FRDC Project No. 2010/535. Fisheries Research Report No. 260. Department of Fisheries, WA. 180 pp.
http://www.fish.wa.gov.au/Documents/research_reports/frr260.pdf

Principle 2

Potter, I.C., Tweedley, J.R., Elliott, M. & Whitfield, A.K. (2015). The ways in which fish use estuaries: a refinement and expansion of the guild approach. *Fish and Fisheries* 16: 230-239. <http://onlinelibrary.wiley.com/doi/10.1111/faf.12050/pdf>

Metcalf, S.J., Dambacher, J.M., Rogers, P., Loneragan, N. & Gaughan, D.J. (2014). Identifying key dynamics and ideal governance structures for successful ecological management. *Environmental Science and Policy* 37: 34-49. <http://www.cdu.edu.au/centres/grld/wp-content/uploads/2014/07/Metcalf-and-Dambacher-et-al.-2014.-mWA-dynamics-and-governance-structure.pdf>

Veale, L. J. (2013). Inter-period comparisons of the ichthyofaunas of two nearby, modified estuaries and the biology of *Pelates octolineatus* (Terapontidae). PhD Thesis, Murdoch University, WA. <http://researchrepository.murdoch.edu.au/18716/>

Ayvazian, S.G., Johnson, M.S. & McGlashan, D.J. (1994). High levels of genetic subdivision of marine and estuarine populations of the estuarine catfish *Cnidogobius macrocephalus* (Plotosidae). *Marine Biology* 118: 25-31.

Principle 3

Department of Fisheries (in press). Research, Monitoring, Assessment and Development (RMAD) Plan 2015 – 2020. Fisheries Occasional Publication No. 122. Department of Fisheries, WA.

Fletcher, W.J. (2014). Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. *ICES Journal of Marine Science*, doi: 10.1093/icesjms/fsu142.
<http://icesjms.oxfordjournals.org/content/early/2014/08/29/icesjms.fs142.full.pdf+html>

