

4-2016

Western Australian Silver-lipped Pearl Oyster (*Pinctada maxima*) Industry

Anthony M. Hart

K. L. Travaille


R. Jones

S. J. Brand-Gardner

F J. Webster

See next page for additional authors

Follow this and additional works at: https://library.dpird.wa.gov.au/fr_msc

 Part of the [Aquaculture and Fisheries Commons](#), [Environmental Monitoring Commons](#), [Natural Resources and Conservation Commons](#), [Natural Resources Management and Policy Commons](#), and the [Sustainability Commons](#)

Recommended Citation

Hart, A M, Travaille, K L, Jones, R, Brand-Gardner, S J, Webster, F J, Irving, A, and Harry, A V. (2016), *Western Australian Silver-lipped Pearl Oyster (Pinctada maxima) Industry*. Department of Fisheries, Perth. Report No. 5.

This report is brought to you for free and open access by the Fishing & aquaculture at Digital Library. It has been accepted for inclusion in WA Marine Stewardship Council report series by an authorized administrator of Digital Library. For more information, please contact library@dpird.wa.gov.au.

Authors

Anthony M. Hart, K. L. Travaille, R. Jones, S. J. Brand-Gardner, F J. Webster, A. Irving, and A. V. Harry

Western Australian Silver-lipped Pearl Oyster (*Pinctada maxima*) Industry

Hart, A., Travaille, K.L., Jones, R., Brand-Gardner, S.,
Webster, F., Irving, A. and Harry, A.V.



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

Western Australian Silver-lipped Pearl Oyster (*Pinctada maxima*) Industry

Hart, A., Travaille, K.L., Jones, R., Brand-Gardner, S.,
Webster, F., Irving, A. and Harry, A.V.



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

Correct citation:

Hart, A., Travaille, K.L., Jones, R., Brand-Gardner, S., Webster, F., Irving, A. and Harry, A.V. (2016). Western Australian Marine Stewardship Council Report Series No. 5: Western Australian Silver-lipped Pearl Oyster (*Pinctada maxima*) Industry. Department of Fisheries, Western Australia. 316pp.

Department of Fisheries
3rd floor, The Atrium
168 – 170 St Georges Terrace
PERTH WA 6000
Telephone: (08) 9482 7333
Facsimile: (08) 9482 7389
Website: www.fish.wa.gov.au
ABN: 55 689 794 771

© Department of Fisheries, Western Australia. April 2016.

ISSN: 2205-3670 (Print) ISBN: 978-1-877098-30-7 (Print)
ISSN: 2205-3689 (Online) ISBN: 978-1-877098-31-4 (Online)

Executive Summary

This report provides a comprehensive description of the pearling (*Pinctada maxima*) industry in Western Australia. The pearling industry is comprised of the wild capture and cultivation of the silver-lipped pearl oyster *Pinctada maxima* in Western Australia's northwest region. This report contains information relevant to assist the assessment of the wild capture of pearl oysters by the Pearl Oyster Fishery (POF) and the related cultivation aspects of the pearling industry against the Marine Stewardship Council's (MSC) *Principles and Criteria for Sustainable Fishing v2.0*. The cultivation of hatchery propagated pearl oysters that also occurs in conjunction with the cultivation of wild caught pearl oysters is not part of the MSC assessment. Where relevant however, information on this component of the industry has been included for completeness.

The first part of this document (Sections 1 to 4) provides an overview of the pearling industry and the aquatic environment in which it operates, including information about the biology of pearl oysters, the development of the wild collection fishery and cultivation industry, fishing and cultivation methods and gear used, the management system in place, and external factors that may influence fishery operations and / or pearl oyster stocks. The remainder of document provides more detailed information for assessing the pearling industry against the performance indicators under MSC Principles 1, 2 and 3.

MSC Principle 1 (Sections 5 to 9) provides information to assess the status of the target species' stocks. These sections provide information on the current status of the silver-lipped pearl oyster stock and include a description of the stock assessment, harvest strategy and genetic management employed for ensuring the future sustainability of this resource.

MSC Principle 2 (Sections 10 to 14) relates to the impact of the wild collection fishery and the pearl cultivation industry on the marine environment in which it operates. These sections include, or point to, all currently-available information on the catch of non-target species, interactions with endangered, threatened or protected species, as well as a description of the habitats and ecosystem in which the industry operates and any impacts on habitat and ecosystem structure and function. Where detailed quantitative data is not available, a risk assessment approach has been used to identify fishery and industry specific issues and to assess the level of risk associated with the issues in question. The issues identified and their associated risk ratings are provided throughout this report, where relevant.

MSC Principle 3 (Sections 15 to 16) provides information to assess the governance and management in place for the pearling industry. Governance includes an overview of the local, national and international legal frameworks relevant to the management of the pearling industry, a description of the roles, responsibilities and consultation processes undertaken with stakeholders and the long-term objectives used to guide decision making. These sections also include information on the fishery-specific management system, including fishery-specific objectives, the decision-making process, compliance and enforcement and an evaluation of the performance of this management system.

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 the pearling industry in Western Australia, it is by no means meant to be the only source of information for assessment. If there is uncertainty regarding any parts of the descriptions and information herein, the referenced material and/or relevant stakeholders should be consulted, with any such issues to be covered in subsequent updates of this document. This document should also be read in conjunction with all other associated management and research publications referenced herein.

Table of Contents

1. Aquatic Environment	1
2. Fishery Information	3
2.1 Fishery development	3
2.2 Current fishing activities	5
2.3 Fishing and cultivation methods.....	5
2.3.1 Wild collection.....	6
2.3.2 Cultivation.....	13
2.4 Management arrangements.....	18
2.4.1 Legislation and policy.....	20
2.4.2 Industry initiatives	28
2.5 Risk assessments	30
2.5.1 Cultivation of pearls.....	30
2.5.2 Wild capture fishery.....	32
2.5.3 2015 Ecological Risk Assessment of the pearling industry.....	34
2.6 Export approval	38
3. Species and Stock Description.....	39
3.1 Silver-lipped pearl oyster, <i>P. maxima</i>	39
3.1.1 Taxonomy and distribution.....	39
3.1.2 Stock structure	40
3.1.3 Life history.....	41
4. External Influences	48
4.1 Catch from other fisheries	48
4.1.1 Customary use.....	48
4.2 Environmental factors	49
4.2.1 Cyclones.....	49
4.2.2 Disease	49
4.3 Market influences	50
4.3.1 Global demand	50
4.4 Tourism	50
4.5 State commercial fisheries.....	51
4.6 Commonwealth fisheries	52
4.7 Oil and gas industry.....	52

4.8 Shipping and ports	53
4.9 Introduced pests and diseases	54
MSC Principle 1	55
5. Stock Status	55
5.1 Current stock status	55
5.1.1 Stock status in relation to target reference points	56
5.2 Genetic outcome	56
6. Stock Assessment	57
6.1 Stock assessment methods	57
6.1.1 Assessment of the culture component of the POF	57
6.1.2 Assessment of larger pearl oysters (>175 mm SL)	71
6.1.3 Appropriateness of assessment	77
6.1.4 Assessment approach relative to reference points	78
6.1.5 Uncertainty in assessment	78
6.1.6 Evaluation of assessment	78
6.1.7 Peer review of assessment	79
7. Harvest Strategy	80
7.1 Harvest strategy framework	81
7.1.1 Design	81
7.1.2 Evaluation	82
7.1.3 Monitoring	82
7.1.4 Harvest strategy review	83
7.2 Reference points	83
7.2.1 Culture pearl oysters (120 to 175 mm SL)	83
7.2.2 Larger pearl oysters (>175 mm SL)	85
7.2.3 Appropriateness of reference points	85
7.2.4 Low trophic level species target reference point	86
7.3 Harvest control rules	86
7.3.1 Design and application	86
7.3.2 Accounting for uncertainties	88
7.3.3 Evaluation	88
7.4 Information and monitoring	88
7.4.1 Range of information	88

7.4.2 Monitoring	89
7.4.3 Comprehensiveness of information and uncertainties	99
8. Genetic Management	100
9. Genetic Information	102
MSC Principle 2.....	103
10. Primary and Secondary Species.....	103
10.1 Pearling industry impacts	103
10.1.1 Biofouling organisms.....	103
10.1.2 Risk assessment outcomes	104
10.2 Management strategy.....	105
10.3 Information and monitoring	106
11. Endangered, Threatened and Protected Species	107
11.1 Overview	107
11.2 Pearling industry impacts	111
11.2.1 Risk assessment outcomes	111
11.3 Management strategy.....	112
11.4 Information and monitoring	114
12. Habitats	115
12.1 Overview	115
12.1.1 Exmouth Gulf.....	116
12.1.2 Pilbara Coast.....	120
12.1.3 Kimberley Coast	124
12.2 Marine Protected Areas	141
12.2.1 Marine Park Zoning.....	142
12.3 Pearling industry impacts	146
12.3.1 Wild collection.....	146
12.3.2 Dump and holding sites	147
12.3.3 Pearl oyster farm leases	148
12.3.4 Risk assessment outcomes	153
12.4 Management strategy.....	154
12.5 Information and monitoring	155
13. Ecosystem	157
13.1 Overview	157

13.2 Trophic modelling	157
13.2.1 North West Shelf Region — North West Cape to Dampier Peninsula.....	158
13.2.2 Kimberley Shelf Region — Dampier Peninsula to western Joseph Bonaparte Gulf	163
13.2.3 Western Joseph Bonaparte Gulf Shelf Region.....	166
13.3 Pearling industry impacts	167
13.3.1 Risk assessment outcomes	170
13.4 Management strategy.....	170
13.5 Information and monitoring	172
14. Translocation.....	173
14.1 Overview	173
14.2 Pearling industry impacts	174
14.2.1 Risk assessment outcomes	174
14.3 Management strategy.....	175
14.4 Information and monitoring	177
MSC Principle 3.....	178
15. Governance and policy	178
15.1 Legal and/or customary framework.....	178
15.1.1 National and State legislative framework	178
15.1.2 Relevant fisheries legislation	180
15.1.3 Management framework	181
15.1.4 Memorandums of Understanding (MoUs).....	185
15.1.5 Resourcing the management process	185
15.1.6 Resolution of disputes.....	186
15.1.7 Respect for rights	186
15.1.8 Customary fishing in WA	188
15.2 Consultation, roles and responsibilities	189
15.2.1 Roles and responsibilities	189
15.2.2 Consultation processes.....	193
15.2.3 Participation	198
15.3 Long-term objectives.....	201
16. Fishery-specific management systems.....	203
16.1 Fishery specific management objectives	203
16.1.1 Harvest strategy	204

16.2 Decision-making processes	205
16.2.1 Annual processes	206
16.2.2 Long-term processes	208
16.2.3 Responsiveness of processes.....	209
16.2.4 Use of precautionary approach	210
16.2.5 Accountability and transparency.....	210
16.2.6 Approach to disputes.....	212
16.3 Compliance and enforcement	212
16.3.1 Monitoring, Control and Surveillance (MCS) Systems.....	213
16.3.2 Applying sanctions.....	221
16.3.3 Level of compliance.....	222
16.3.4 Systematic non-compliance	223
16.4 Monitoring and management performance evaluation.....	223
16.4.1 Evaluation coverage.....	223
16.4.2 Review of the management system.....	224
17. References.....	226
17.1 General References (Sections 1– 4)	226
17.2 Principle 1 References (Sections 5 – 9).....	230
17.3 Principle 2 References (Sections 10 – 14).....	232
17.4 Principle 3 References (Sections 15 – 16).....	242
18. Appendices.....	244
Appendix A. Pearl Oyster Translocation Protocol.....	244
Appendix B. Memorandum of Understanding.....	263
Appendix C. Licence types	266
Appendix D. Pearl Oyster Farm Lease.....	272
Appendix E. Daily Log Sheet.....	276
Appendix F. Example of statistical reporting grid	277
Appendix G. Commercial length-frequency monitoring datasheet	278
Appendix H. Recruitment and habitat monitoring datasheet	279
Appendix I. Whale Management Policy and Protocol	280
Appendix J. Invitation to MSC Stakeholder briefing	290
Appendix K. Notice of Pearling or Hatchery Activity Form (P2)	292
Appendix L. Transport Log Sheet	294

Appendix M. Certificate of Health	295
Appendix N. Daily Patrol Contacts Form	296

List of Tables

Table 2.1. Primary licence types issued under Section 23 of the <i>Pearling Act 1990</i> in relation to the WA pearling industry	26
Table 2.2. Risk ratings of impacts from pearl farm activities. Source: Wells & Jernakoff 2006; PPA 2004.	32
Table 2.3. Risk ratings of impacts from commercial fishing of <i>P. maxima</i> . Sources: Fletcher et al. 2006; DoF 2008; DoF 2013.	34
Table 2.4. Summary of fishery objectives, ecological components, assessed issues and identified risk ratings for the WA <i>P. maxima</i> Pearling Industry at the 2015 ecological risk assessment workshop.....	36
Table 6.1. Spatial estimates of area of fishing grounds (Location), number of survey drifts undertaken, mean densities, and total population estimates of pearl oysters > 175 mm SL in Zone 2/3 of the POF.....	75
Table 7.1 Summary of reference points, performance measures and control rules for <i>P. maxima</i> harvested by the POF	80
Table 7.2. Summary of current research and monitoring activities for the Pearl Oyster Fishery. CDR – Catch Disposal Records (i.e. formal quota reporting).	89
Table 7.3. Recruitment (‘piggyback spat’) monitoring of <i>Pinctada maxima</i> in Western Australia, showing the number (<i>n</i>) and per cent (%) of adult oysters caught commercially that were examined for the presence of spat.	95
Table 12.1. Biogeomorphological units identified by Lyne et al. (2006) within Exmouth Gulf	118
Table 12.2. Mapping units identified at Level 3C. Source: Lyne et al. (2006)	123
Table 13.1. Relative importance of trophic groups as proportions of the total estimated fish biomass in the northwest shelf system and as proportions of fish eaten in the system. Source: Bulman (2006)	161
Table 16.1 Summary of harvest strategy for the POF with management objectives and operational objectives	204
Table 16.2. Contact details for the POF for 2010 – 2014.....	220
Table 16.3 Number and types of offences in the Wildstock Pearl Oyster Fishery	222

List of Figures

Figure 1.1. Surface currents of Western Australia (Source: Commonwealth of Australia [CoA] 2007)	2
Figure 2.1. Historical export (tonnes) of MOP products and phases of MOP production in WA	4
Figure 2.2. Overview of the Western Australian pearling industry, which integrates the capture of wild oysters with hatchery-produced stock for pearl, MOP and oyster meat production.....	5
Figure 2.3. Fishing boundaries and zones of the WA Pearl Oyster Fishery, including holding sites and farm lease areas	6
Figure 2.4. Location of main ‘fishing patches’ in Zone 1 (top) and Zones 2/3 (bottom) of the WA Pearl Oyster Fishery	7
Figure 2.5. Pearl oyster fishing vessel (left) and diver (right)	9
Figure 2.6. Schematic of pearl oyster diving operations (top) and photo of diver collecting a pearl oyster (bottom). Source: PPA 2008a.....	9
Figure 2.7. Panel containing pearl oysters. Source: PPA 2008a.....	10
Figure 2.8. Total catch (in numbers) of <i>Pinctada maxima</i> from the POF and catch by management zone (see Figure 2.3 for spatial boundaries).....	11
Figure 2.9. Total catch (in numbers) of <i>Pinctada maxima</i> compared with the TAC for the Zone 2 and Zone 3 management zones (see Figure 2.3 for spatial boundaries). Numbers refer to “culture shell” only and 2014 data is incomplete.	12
Figure 2.10. Total nominal effort (dive hours) in the Zone 2/3 Pearl Oyster Fishery between 1979 and 2014. Note – 2014 data incomplete at time of writing.	12
Figure 2.11. Pearl oyster spat. Source: PPA 2008a	13
Figure 2.12. Seeding of pearl oyster. Source: PPA 2008a.....	15
Figure 2.13. Typical cleaning boat attached to a pearl longline (top) and a ‘panel’ of oysters being returned to the sea after cleaning and inspection on-board the vessel (bottom). Source: PPA 2008a, J. Andrews 2014	17
Figure 3.1. <i>Pinctada maxima</i> in its (a) natural habitat, and (b) processed for sale.....	39
Figure 3.2. Distribution of silver-lipped pearl oysters (<i>Pinctada maxima</i>) and areas of historical and current wild fisheries and pearl farms.	40
Figure 3.3. Per cent frequency distribution of sex by size for <i>Pinctada maxima</i> . Data sourced from Hart and Joll (2006).....	41
Figure 3.4. Fecundity estimates as a function of shell length in mm for two different methods. Figure modified from Hart and Friedman (2004).	42

Figure 3.5. Morphometric measurements commonly used to measure the morphology of <i>Pinctada maxima</i>	43
Figure 3.6. Dorso-ventral measurements (DVM) in comparison to (a) anterior-posterior measurement (APM) and (b) shell thickness.	44
Figure 3.7. von Bertalanffy growth curves for each population of <i>Pinctada maxima</i> (A – Lacepede Islands; B – 80 Mile Beach; C – Exmouth Gulf) and annualised growth increment residuals. The exploited phase of the life cycle in each population is also shown.	45
Figure 3.8. Natural mortality (M) curve for <i>Pinctada maxima</i> sampled at 4 populations. A) 80 Mile – Inshore shallow, B) 80 Mile – Offshore shallow, C) Compass Rose, D) Lacepede Islands.	46
Figure 4.1. Custom distribution and movement of Kimberley Pearl Shell (Source: Akerman and Stanton 1994).	49
Figure 4.2 Oil and gas industry wells and exploration areas in the WA Pearl Oyster Fishery area	53
Figure 4.3 Major ports and shipping activity in the WA Pearl Oyster Fishery area.....	54
Figure 6.1. Spatial distribution of catch, effort and catch rates in 2014 for <i>Pinctada maxima</i> in Zone 2 and Zone 3 of the Pearl Oyster Fishery.	58
Figure 6.2. Long term trends in catch (total pearl oysters), effort (Dive Hrs) and catch rates in the six highest producing statistical grids in the pearl oyster fishery.	59
Figure 6.3. A comparison of standardised catch rates and raw catch rates in Zone 2 of the POF.	61
Figure 6.4. A comparison of standardised catch rates from the main fishing grounds (pearl oyster “patches”) of the Zone 2 pearl oyster fishery (averaged over 2003 – 2014).	61
Figure 6.5. Catch length frequency of <i>Pinctada maxima</i> from the 2014 ‘culture’ component of the POF, for the whole fishery and individual pearl oyster “patches” (6% less than 120 mm).	62
Figure 6.6. Catch length frequency of <i>Pinctada maxima</i> from the 2014 ‘culture’ component of the POF, for individual pearl oyster “patches” in the south of 80 Mile Beach. ‘Shoonta Hill has not been fished since 1995.	63
Figure 6.7. Long-term trends in average length of pearl oysters in the POF.....	63
Figure 6.8. Population length frequency of <i>Pinctada maxima</i> from surveys in the Zone 2 fishery between 2009 and 2014.	64
Figure 6.9. Standardised abundance (oyster caught per hour; \pm CL) of pre-recruit (<120 mm) and recruited (120 – 175 mm) <i>Pinctada maxima</i> in the Zone 2 Pearl Oyster Fishery between 2001 and 2014.....	65

Figure 6.10. Length frequency distribution of newly settled <i>Pinctada maxima</i> (Age 0+, 1+) between 2009 and 2014.....	67
Figure 6.11. Standardised 0+ spat abundance (per 1000 adult shells; \pm CL) in the Zone 2 Pearl Oyster Fishery.....	68
Figure 6.12. (a) Survival curve of pearl oysters in the wild (unfished trajectory); (b) relative reproductive output of each sex (males, females) from a cohort of oysters throughout its life (assumed maximum age = 25 years).....	69
Figure 6.13. 2012 forecast model: abundance (SCPUE) of <i>P. maxima</i> in the Zone 2 fishery in year <i>n</i> , expressed as function of 0+ spat settlement. The prediction line is an expression of the formula at the top. Blue numbers are the data for year of the SCPUE (12 = 2012), pink numbers are the predicted abundance (+ SE) for future years (13 = 2013; 14 = 2014).....	70
Figure 6.14. 2014 forecast model: abundance (SCPUE) of <i>P. maxima</i> in the Zone 2 fishery in year <i>n</i> , expressed as function of 0+ spat settlement. The prediction line is an expression of the formula at the top. Blue numbers are the data for year of the SCPUE (12 = 2012), pink numbers are the predicted abundance (+ SE) for future years (15 = 2015; 16 = 2016).....	70
Figure 6.15. Spatial location of areas surveyed for larger sized shell (>175mm) abundance in 1999, 2001 and 2012/13.....	71
Figure 6.16. Spatial distribution of catch, effort and catch rates of larger pearl oysters (>175mm) used for Mother of Pearl (MOP) in Zone 2 during 2012 and 2013.	72
Figure 6.17. Spatial variation in length frequency of larger pearl oysters from research surveys in Zone 2 of the POF.....	73
Figure 6.18. Standardised catch rates (oyster caught per hour; \pm CL) of larger sized pearl oysters (> 175 mm) used for Mother of Pearl (MOP) in the Zone 2/3 POF between 2001 and 2014.....	74
Figure 6.19. (A) Total SHL range for larger pearl oysters used for Mother of Pearl (MOP) (B) SHL range by the major fishing grounds. The yellow triangles are the average annual harvest for the 2012/2013 fishing years.	76
Figure 7.1. SCPUE performance measure, and associated target, threshold and limit levels of culture pearl oysters (120 to 175 mm). Unstandardised CPUE is shown for comparison.....	84
Figure 7.2 Preliminary fishery-independent SCPUE performance measure, and associated target, threshold and limit levels for larger pearl oysters (>175 mm).....	85
Figure 7.3. Harvest control rule for <i>P. maxima</i> in the Zone 2 fishery. The blue numbers are the data (SHL and SCPUE) for each historical year (12 = 2012 etc.), the green numbers are the predicted SHL for future years (15 = 2015; 16 = 2016 etc.).....	86
Figure 7.4. Raw CPUE of ‘culture’ (120 – 175 mm SL) and larger (\geq 175 mm SL; MOP) sized animals in the Zone 2/3 <i>P. maxima</i> fishery.	91

Figure 7.5. Length-frequency composition of <i>Pinctada maxima</i> by statistical grid during commercial monitoring in 2003.....	92
Figure 7.6. Length-frequency composition of <i>Pinctada maxima</i> from population surveys in 2007 and 2008. A large recruitment pulse beginning to enter the fishery in 2008 is observed as a result of the good 0+ settlement in 2005. The lower and upper commercially fished lengths are the dashed blue lines. “Chicken” are undersize oysters, ‘Culture’ are the targeted oysters, “MOP” are the broodstock.	93
Figure 7.7. <i>Pinctada maxima</i> spat found on commercially fished adult shell. A) Age 0+ spat, 17mm DVM, approximately 4 months old; B) Age 1+ spat, 57 mm DVM, approximately 16-18 months old.	94
Figure 7.8. An example of size frequency of <i>Pinctada maxima</i> spat collected during recruitment surveys in 2009 and 2010. Age classes (0+; 1+) delineated by red dashed lines.	95
Figure 7.9. Standardised 0+ spat abundance (per 1000 adult shells; \pm CL) in the Zone 2 Pearl Oyster Fishery.	96
Figure 7.10. Proportion of different habitats fished over time by the Pearl Oyster Fishery. Habitat categories (garden, potato, etc.) are described in more detail in Section 12.....	97
Figure 7.11. Catch rates of <i>Pinctada maxima</i> in the Zone 2 fishery compared with the Southern Oscillation Index (SOI) for the period 1979 to 2014.....	98
Figure 7.12. Environmental variables during December to February in the Pearl Oyster Fishery from 1980 to 2010.....	98
Figure 12.1 Distribution and intensity of fishing effort in the POF for larger pearl oysters used for Mother of Pearl (MOP) (top) and culture pearl oysters (bottom).	115
Figure 12.2. Biogeomorphic units of Exmouth Gulf (Source: Lyne et al. 2006)	119
Figure 12.3. Primary biotopes of Exmouth Gulf region (Source: Lyne et al. 2006)	120
Figure 12.4. Level 3C units for the Pilbara Coast from Onslow north to Breaker Inlet. Source: Lyne et al. (2006)	124
Figure 12.5. Map of Level 4 habitats for the Pilbara Coast from Onslow north to Breaker Inlet. Source: Lyne et al. (2006)	124
Figure 12.6. Location of sites in the Kimberley Nearshore Ecosystem that were considered by the Northern Development Taskforce as potential sites for a multi-user LNG processing hub. Source: DEC (2008).....	127
Figure 12.7. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects at Gourdon Bay. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)	129

Figure 12.8. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects from Quondong Point to Coulomb Point. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)	130
Figure 12.9. Combined benthic habitat map (excluding seagrass) of the James Price Point coastal region (left) and observed distribution of seagrass across the study area based on towed video surveys during June 2008 and November 2009 (right). Source: SKM (2010)	133
Figure 12.10. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects at North Head and Perpendicular Head. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)	134
Figure 12.11. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects at Packer Island. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)	135
Figure 12.12. Preliminary marine benthic habitat map of the Anjo Peninsula area. Source: DEC (2008)	139
Figure 12.13. Existing and proposed State marine parks that overlap with the WA pearl oyster fishery area	141
Figure 12.14. Proposed Commonwealth marine reserve network in the north-west region of WA and overlap with the WA pearl oyster fishery zones	142
Figure 12.15. Detail of zoning scheme for Montebello Islands Marine Park north (left) and south (right). Source: DEC 2007	144
Figure 12.16. Pearling leases of the Montebello / Lowendal / Barrow Islands at time of Marine Park zoning gazettal. Source: DEC 2007	145
Figure 12.17. Pearling sites within and adjacent to the Lalang-garram / Camden Sound Marine Park in 2013. Source: DPaW 2013	145
Figure 12.18. Example of the two main habitat types encountered by the WA pearling industry: (a) ‘potato’ bottom (with pearl oyster) and (b) ‘garden’ bottom.	146
Figure 12.19. Map of Australia showing Kimberley coast region and study areas: Cygnet Bay, Port George and Vansittart Bay. Source: Jelbart et al. (2011)	150
Figure 12.20. The percentage of total organic matter, nitrogen and carbon in the soft sediments at each bay over two years sampling among farm (dashed line) and reference locations (solid lines). Farm = □, Reference 1 = —, Reference 2 = ▲, Reference 3 = ×, Reference 4 = ●. Source: Jelbart et al. (2011)	151
Figure 12.21. Number of macrobenthic taxa (species to families) and individuals per 0.1 m ² of soft sediments at each bay over two years sampling among farms (F) and reference (R) locations. Source: Jelbart et al. (2011)	152
Figure 13.1. Food web of the North West Shelf. Coloured arrows represent flows from boxes of the same colour. Source: Bulman (2006)	160

Figure 13.2. Trophic structures of the North West Shelf region. Source: DEWHA (2008)..	163
Figure 13.3. Habitat diagram of the Kimberley Shelf region showing selected important drivers and features. Source: Brewer et al. (2007).....	165
Figure 13.4. Conceptual trophic model of the Kimberley Shelf region showing information on the extensive habitat in the coastal and central shelf region (left) and the important bank and channel habitats in the central and southern areas (right). Source: Brewer et al. (2007)	165
Figure 13.5. Habitat diagram of the western Joseph Bonaparte Gulf region showing selected important drivers and features. Source: Brewer et al. (2007)	166
Figure 13.6. Schematic trophic model of the western Joseph Bonaparte Gulf region showing information on the extensive habitat in the coastal and central shelf region (left) and a less extensive, but important mid-shelf habitat (right). Source: Brewer et al. (2007)	167
Figure 15.1. Outline of risk-based planning cycle used by the Department to determine annual priorities and activities.	184
Figure 15.2 Pearl Oyster display in the foyer of the Department of Fisheries Broome Office.	200
Figure 16.1 Annual TAC setting process for the POF	208

List of Abbreviations

AAC	Aquaculture Advisory Committee
AFMA	Australian Fisheries Management Agency
AFZ	Australian Fishing Zone
AIMS	Australian Institute of Marine Science
AMM	Annual Management Meetings
APM	Anterior-posterior Measurement
AQWA	Aquarium of Western Australia
ARMA	Aquatic Resource Management Act
ARMS	Aquatic Resource Management Strategy
ARUP	Aquatic Resource Use Plan
BRUVS	Baited Remote Underwater Video Stations
CAES	Catch and Effort Statistics
CAG	Catch and Grow
CALM	<i>Conservation and Land Management Act 1984</i>
CAMBA	China-Australia Migratory Bird Agreement
CoA	Commonwealth of Australia
CDR	Catch and Disposal Record
CEO	Chief Executive Officer
CITES	Convention on International Trade in Endangered Species
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEC	Department of Environment and Conservation
DEH	Department of Environment and Heritage
DEWHA	Department of Environment, Water, Heritage and the Arts
DG	Director General
DOF	Department of Fisheries

DotE	Commonwealth Department of the Environment
DPaW	Department of Parks and Wildlife
DPC	Daily Patrol Contact
DVM	Dorso-ventral Measurement
EBFM	Ecosystem Based Fisheries Management
EMS	Environmental Management Services
EPBC	<i>Environment, Protection and Biodiversity Conservation Act 1999</i>
ESD	Ecological Sustainable Development
ETP	Endangered, Threatened and Protected Species
FHPA	Fish Habitat Protection Areas
FMA	<i>Fisheries Management Act 1991</i>
FMP	Fisheries Management Papers
FMO	Fisheries and Marine Officers
FOP	Fisheries Occasional Papers
FRDC	Fisheries Research and Development
FRMA	<i>Fish Resources Management Act 1994</i>
GFC	Global Financial Crisis
GLM	Generalised Linear Model
GPS	Global Positioning System
GVP	Gross Value of Production
HAC	Hatch and Catch
ICU	Industry Consultation Unit
IFAAC	Integrated Fisheries Advisory Allocation Committee
IFM	Integrated Fisheries Management
IRCE	International Risk Consultants - Environment
JAMBA	Japan-Australia Migratory Bird Agreement
JBG	Joseph Bonaparte Gulf

KNE	Kimberley Nearshore Ecosystem
LADS	Laser Airborne Depth Survey
LC	Least Concern
LENS	List of Exempt Native Species
LML	Legal Minimum Length
LNG	Liquefied Natural Gas
MAC	Management Advisory Committee
MCS	Monitoring, Control and Surveillance
MPG	Ministerial Policy Guidelines
MPRA	Marine Parks and Reserves Authority
MOP	Mother of Pearl
MoU	Memorandum of Understanding
NCB	North Coast Bioregion
NDT	Northern Development Taskforce
NGO	Non-Government Organisation
NT	Northern Territory
NWMR	North West Marine Region
NSW	North West Shelf
NWSJEMS	North West Shelf Joint Environmental Management Study
OCP	Operational Compliance Plan
OCS	Offshore Constitutional Settlement
OOD	Oyster Oedema Disease
PA	<i>Pearling Act 1990</i>
PAP	Prosecution Advisory Panel
PI	Pearling Inspectors
PIRC	Pearl Industry Review Committee
PNE	Pilbara Nearshore Ecosystem

POF	Western Australian Pearl Oyster Fishery (<i>Pinctada maxima</i> only)
PPA	Pearl Producers Association
PR	<i>Pearling (General) Regulations 1991</i>
RFBL	Recreational Fishing from Boat Licence
RFW	Recfishwest
RMAD	Research, Monitoring, Assessment and Development (Plan)
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RSD	Regional Services Division
SAT	State Administrative Tribunal
SAWG	Stock Assessment Working Group
SCPUE	Standardised Catch Per Unit Effort
SKM	Sinclair Knight Merz
SL	Dorso-ventral shell length, excluding the fingers
SSA	Seafood Services Australia
TAC	Total Allowable Catch
TAE	Total Allowable Effort
TWRA	Tennessee Wildlife Resource Agency
UoA	Unit of Assessment
VMS	Vessel Monitoring System
WA	Western Australia
WAFIC	Western Australian Fishing Industry Council
WAMSI	Western Australian Marine Science Institute

1. Aquatic Environment

This document provides a cumulative description of the WA pearling industry (pearling industry), which includes the wild capture, hatchery production and cultivation of pearls of the Indo-Pacific silver-lipped pearl oyster *Pinctada maxima* in WA's northwest region. Under the ecosystem-based fisheries management (EBFM) framework adopted by the Department of Fisheries WA (the Department), the Pearl Oyster Fishery (POF) is managed as part of the North Coast Bioregion (NCB). This region has a unique combination of features that distinguish it from other marine bioregions around Australia, including a wide continental shelf, very high tidal regimes, high cyclone frequency, unique current systems and warm oligotrophic surface waters (Brewer et al. 2007).

The NCB exhibits monsoonal climatic patterns, with a pronounced cyclone season between December and March each year. During this time, the northern Kimberley region experiences a wet season with large influxes of run-off, and the Pilbara is subject to sporadic and intense storms (Department of Environment, Heritage, Water and the Arts [DEWHA] 2008). The region is subject to very high evaporation rates (three metres per year), although the Pilbara coastline is more arid than the Kimberley, due to its lower annual rainfall (Fletcher and Santoro 2014). Ocean temperatures range between 22° C and 33° C, with localised higher temperatures in coastal waters, particularly along the Pilbara coastline (Fletcher and Santoro 2014).

Because the region is shallow (over 40 % of the NCB is less than 200 metres deep), surface currents exert a strong influence over the bioregion's physical and ecological processes. Major surface currents in the NCB include the Indonesian Throughflow, the Leeuwin Current, the South Equatorial Current and the Eastern Gyral Current (Figure 1.1). Additionally, the Holloway and Ningaloo Currents are seasonal surface currents (DEWHA 2008; Figure 1.1). The main surface currents are globally unique in that they have a poleward flow (Pearce and Walker 1991) and carry warm, low salinity, oligotrophic waters southward along the WA coast.

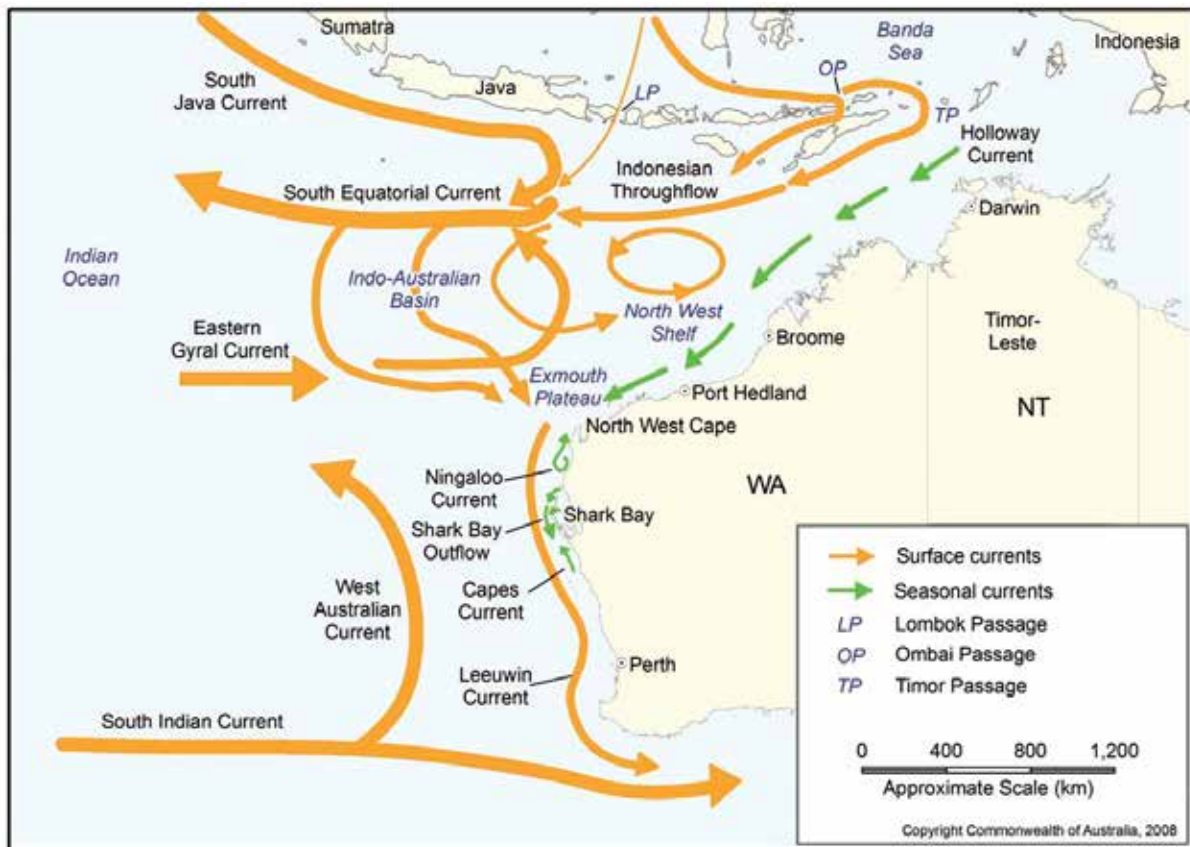


Figure 1.1. Surface currents of Western Australia (Source: Commonwealth of Australia [CoA] 2007)

Coastal geography is extremely variable within the NCB and provides for a variety of habitats, including sand / mud flats, mangroves, seagrasses, macroalgae, filter-feeding communities, coral communities and soft-bottom areas. The NCB has a high level of species diversity, although endemism is relatively low. Most species are tropical and are found along Indonesia and the west Pacific (DEWHA 2008).

Fish communities play an important ecological role within the bioregion, and small pelagic fish are believed to comprise a significant portion of the fish biomass throughout the NCB (approx. one-third of the total biomass; Bulman 2006). These fish species inhabit a range of marine environments and form an important link in the bioregion's trophic systems (Mackie et al. 2007).

The NCB also provides internationally-important breeding and feeding grounds for a number of threatened and migratory marine species, including humpback whales, which mate and give birth in the waters off the Kimberley coast. Significant turtle rookeries are also found on coastal beaches and offshore islands. The bioregion also marks the end point of the East Asian-Australian Flyway for millions of shorebirds that migrate every year from breeding grounds in the Northern Hemisphere (DEWHA 2008).

2. Fishery Information

The WA pearling industry is the world's top producer of the highly-prized, silver-white South Sea Pearls, which come from the silver-lipped pearl oyster, *P. maxima*. The pearls produced in WA are well regarded in the industry worldwide, with the value of cultured pearls and other related products considered to be approximately AUD 61 million in 2013 (Hart et al. 2014).

2.1 Fishery development

Commercial fishing for pearl oysters in Western Australia began in the Shark Bay region in the 1850s and was initially based on the smaller *Pinctada albina* pearl oysters that were harvested from intertidal banks at low tide or were dredged from shallow water. Later, pearl oyster shells became more valuable than pearls, and the industry was based on production of mother-of-pearl (MOP). During this time, no regulations were in place to manage the industry and ensure that the harvest was sustainable. As a result, the *P. albina* pearl stocks became depleted, and the fishery collapsed. This prompted two independent studies of the commercial fishery and resulted in the *Shark Bay Pearl Fishery Act 1892*.

In the 1860s, *P. maxima* was discovered near Nickol Bay, and the pearling industry started to expand northwards. By the 1880s, the larger pearl oysters became the focus of the pearling industry due to their use as MOP for buttons in the clothing industry and inlay for furniture. In the early 1890s, surface air supply or “hard-hat” diving became the dominant fishing method, enabling the pearling industry to effectively fish pearl oyster beds in deeper waters. By 1910, there were nearly 400 luggers and 3500 people in the pearling industry harvesting up to approximately two million pearl oysters per year — or up to 75 % of the world production (Southgate et al. 2008; Malone et al. 1988).

The emergence of plastics around the time of World War I, and the acceptance of plastic buttons and buckles by consumers, created direct competition for the MOP material. The 1920s and 1930s saw a decline in fishing and MOP production, due to this competition from plastics and the wider effects of the Great Depression. At the same time, the adoption of new technology by the pearling industry, including engine-powered and mechanical air pumps, enabled two divers to operate from each vessel, increasing the average annual harvest per vessel from 3.5 t in 1912 to 12 t in 1936.

During World War II pearling operations in WA almost ceased entirely; however, in 1949 the *Pearling Act Amendment Act 1922*, which prohibited the culture of pearls, was repealed and the pearl culture phase of the pearling industry began to develop. In the early decades, the POF went through cycles of boom and bust, with loss of men and boats from cyclones, injuries from diving, labour and other social problems and fluctuating prices (Figure 2.1; Wells & Jernakoff 2006).

P. maxima pearl culture activities began in Kuri Bay in the Kimberley during the 1950s and by the end of the 1970s, most of the pearling industry had moved into cultured pearl production. The catches of pearl oysters greater than 175mm (used for MOP production) had

declined to less than 300 tonnes. The catch of culture pearl oysters (between 120 and 175 mm shell length) increased to around 400 000 in the same period (Figure 2.1; Wells & Jernakoff 2006, Malone et al. 1988). This shift in targeting different sized pearl oysters saw a change in the location of fishing.

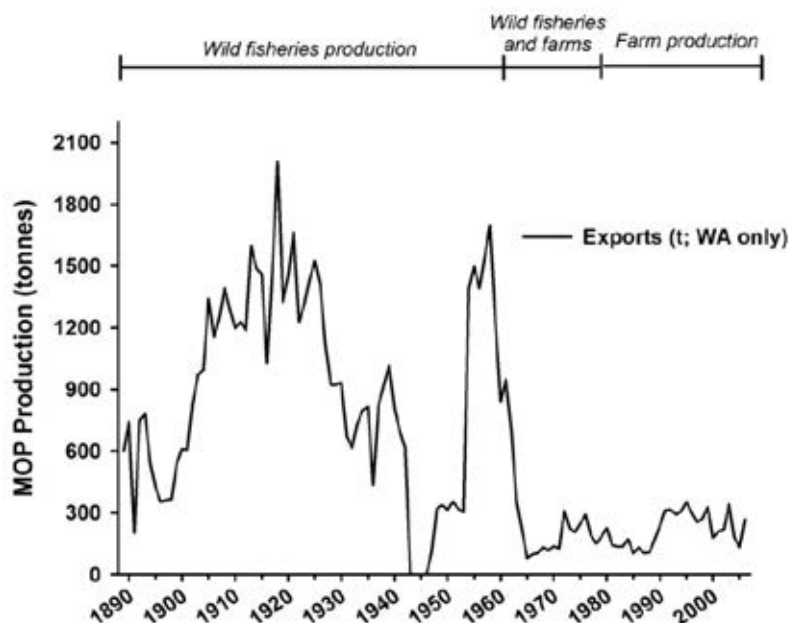


Figure 2.1. Historical export (tonnes) of MOP products and phases of MOP production in WA

In 1980 it was agreed that the prime use of pearl oysters would be for pearl culture, with MOP production a secondary objective. In 1981, each operator utilizing pearl oysters between Kuri Bay and Port Hedland was set an annual quota for the three years from 1982 through 1984. Minimum sizes were set for culture pearl oysters. In 1983 it was decided that any take of pearl oysters for MOP would form part of a licensee's annual quota, and the area to which the quota applied was extended south to Exmouth. During 1985 and 1986, individual companies strictly adhered to the total allowable catch (TAC) and lobbied for protection of the larger female oysters as the breeding stock (previously taken for MOP) to ensure continuity of high levels of recruitment considered necessary for adequate culture pearl oyster abundance (DoF, unpublished report). Due to these changes in targeting, a large number of deeper historical fishing beds were no longer harvested (Fletcher et al. 2006).

The subsequent increase in fishing pressure on nearshore oyster beds, such as Eighty Mile Beach, led to the establishment of the Pearling Industry Review Committee (PIRC) in 1987. PIRC's task was to make recommendations about the future development and management of the pearling industry. A moratorium on the issue of new pearling licences was put in place until the end of 1987, effectively limiting the number of operators to those active in the POF. At that time, there were 11 pearling licensees, with nine licensed to operate in the northern sector of the fishery (Zones 2 and 3; Figure 2.3) and two licensed to operate in the southern sector (Zone 1; Figure 2.3). Catch limits for each licensee were also introduced for culture pearl oysters, as the production and grow-out of pearl oysters from hatcheries was not considered a viable alternative at the time.

The PIRC made a series of recommendations about the management of the resource, including recommendations for quotas to be set by annual stock assessments using catches and catch rate data as reference points, the complete phasing out of fishing for larger sized pearl oysters to support breeding stocks and the zoning of the POF to provide more control over localised fishing pressure and rates of depletion (Malone et al. 1988). The majority of these recommendations have formed the basis for management of the pearling industry since 1988.

2.2 Current fishing activities

The current pearling industry is comprised of three vertically-integrated components: the collection of pearl oysters from the wild (as part of the POF); the production of hatchery-reared pearl oysters; and the seeding of pearls within pearl oysters for grow-out on pearl oyster farm leases (farm lease) (Figure 2.2).

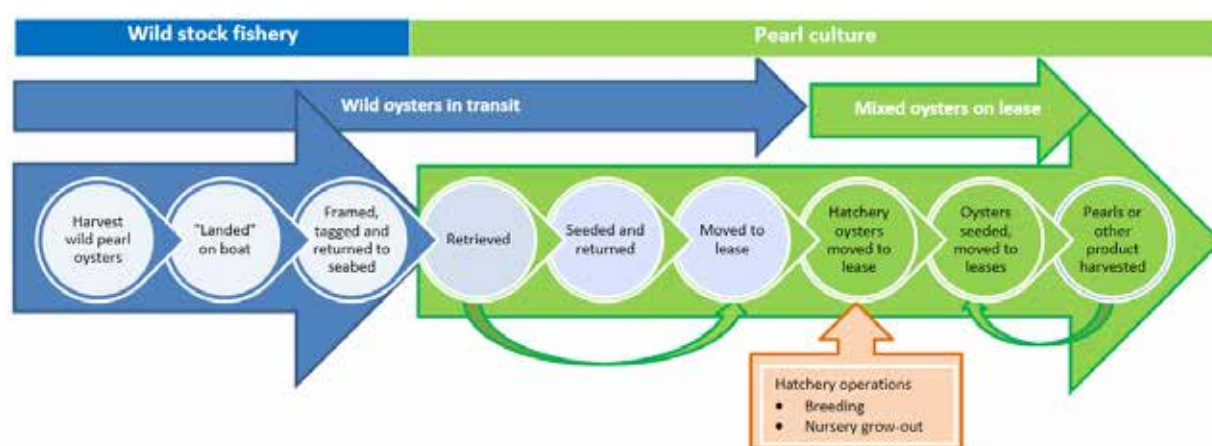


Figure 2.2. Overview of the Western Australian pearling industry, which integrates the capture of wild oysters with hatchery-produced stock for pearl, MOP and oyster meat production

2.3 Fishing and cultivation methods

As part of the pearl production process, pearl oysters are caught in the wild, seeded with a nucleus at sea on board specially-built vessels and are grown out in farm leases for two to three years to produce cultured pearls.

Prior to the development of hatchery technology in the 1990s, the pearling industry relied on the capture of live pearl oysters from the wild, which were seeded to stimulate pearl formation and then moved to farm leases for the grow-out of pearls. In recent decades, the production of pearl oyster spat from hatcheries has become an increasingly important component of the supply of pearl oysters for seeding. The end product from either process is primarily high quality pearls, with a small amount of pearl oyster meat and MOP¹ products.

¹ Note the term Mother of Pearl (MOP) refers to the nacre lining of the inside of the shell. MOP is typically harvested from larger pearl oysters (>175 mm) that provide the highest yield. Although MOP refers to the product, it has also been used to refer to the size class of larger shells themselves, particularly in the context of stock assessment. As pearl oysters are protandrous hermaphrodites, maturing first as males and later changing sex to females, the larger pearl oysters or 'MOP' also comprise the wild female broodstock.

2.3.1 Wild collection

The pearling industry currently comprises 15 wildstock licences that can collectively take pearl oysters from Exmouth Gulf to the Northern Territory (NT) border (see Figure 2.3); however, harvesting is focused between Exmouth Gulf and Cape Leveque, with most pearl oysters collected off Eighty Mile Beach (Figure 2.4). In any given year, there can be 6 – 10 vessels fishing for pearl oysters. There is only one species targeted in the POF, the silver-lipped pearl oyster *P. maxima*, with individuals collected by highly-trained divers towed behind large (~ 35 m long) tender boats (Figure 2.5). Many of these boats have been custom designed for the pearling industry and have a total crew of 10 – 12 people (Fletcher et al. 2006).

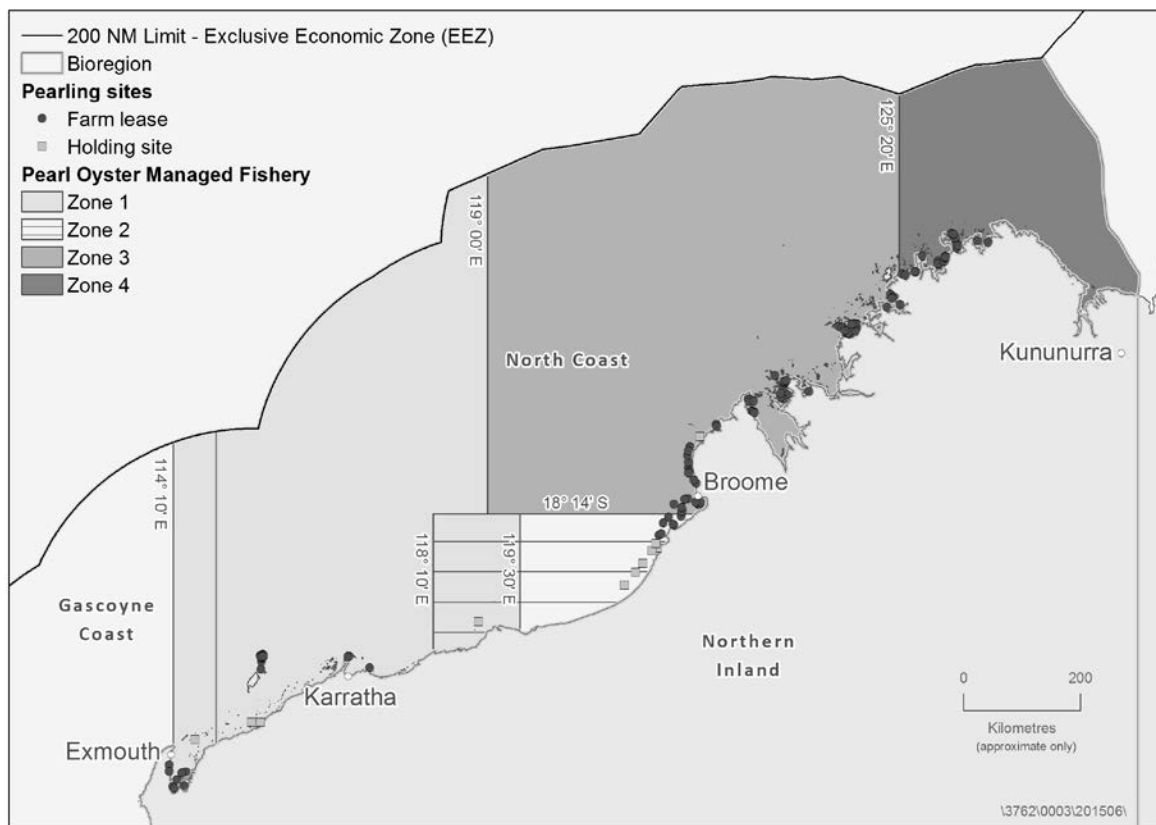


Figure 2.3. Fishing boundaries and zones of the WA Pearl Oyster Fishery, including holding sites and farm lease areas

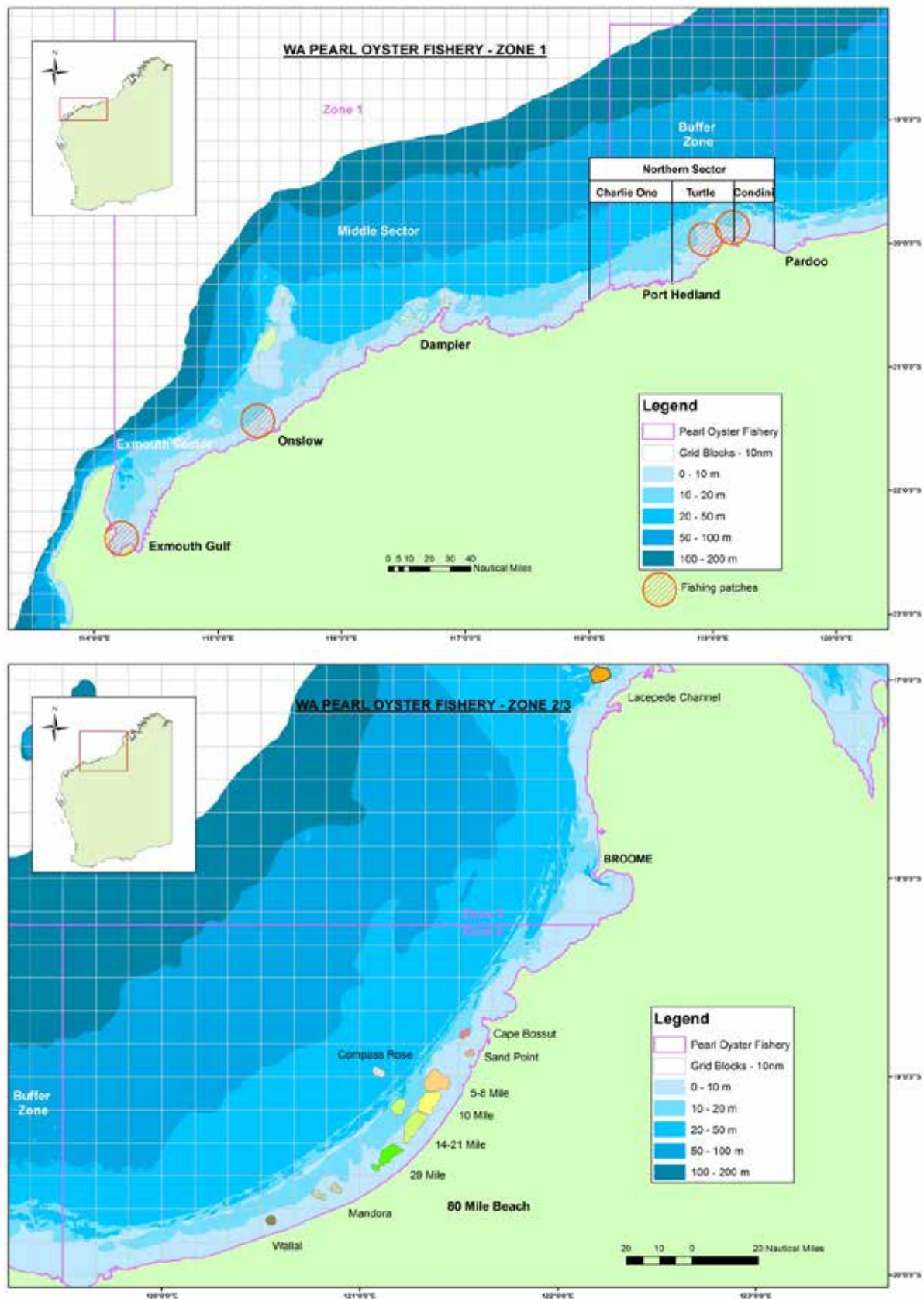


Figure 2.4. Location of main 'fishing patches' in Zone 1 (top) and Zones 2/3 (bottom) of the WA Pearl Oyster Fishery

The POF generally operates for three to four months per year, usually between March and July. Start and end dates varying dependent on current quota and environmental conditions, for example, the presence of cyclones often delays fishing trips. The areas where pearl oysters are collected are subject to extreme tidal ranges (up to 9 m), and consequently have very strong tidal currents. Diving is too difficult and dangerous during the spring tidal periods and is only undertaken for six to twelve days on the neap cycle when currents are substantially reduced (Fletcher et al. 2006).

Fishing for pearl oysters generally involves the extension of booms outwards from each side of the vessel (Figure 2.5), with a number of weighted ropes hung vertically from each boom to a height of approximately one to two metres above the seabed. Most boats use three lines per boom, which allows six divers to work simultaneously. Divers operate on hookah, with air supplied from a surface compressor. Coded signals are used by the head diver to communicate with the crew on the boat in order to control factors like the speed and direction of the boat and height of the weights etc. Since water clarity is paramount to divers being able to identify the appropriate sized oysters, significant effort is put in place to ensure the weight does not strike the sea floor. Therefore, the diver will signal to the vessel to raise the weight according to the sea floor height — thus preventing the weight from striking the bottom (Fletcher et al. 2006).

During fishing activities, the vessel begins “drifting” (towing) at one end of a pearl oyster patch and moves slowly across the patch at a rate of about one knot. The engine remains in gear to maintain steerage of the vessel, but even at minimum speed, the boat moves too fast for the divers, and so a stern drogue is deployed to act as a sea anchor and slow the boat. Ropes attached to the drogue can be manipulated to open the drogue fully and slow the boat or partially close it to increase speed. Each diver wears a neck bag during the dive (Figure 2.5), and as pearl oysters are collected, they are kept in the neck bag until it is full. Only pearl oysters that are deemed of culture shell quality, i.e. the appropriate size and health, are collected. The collected shells are transferred to the holding bag at the end of each weighted rope. The divers swim about 1.5 metres off the seabed to obtain the maximum field of view (Figure 2.6). Even in murky water when the divers swim closer to the bottom, they are still above the bottom substrate. Each diver makes an average of eight to 10 dives in depths of less than 23 m per day, and a good diver aims to collect an average of 250 culture shell pearl oysters per day (Fletcher et al. 2006).

A Code of Practice for diving in the pearling industry has been developed, and in addition to operating their own hyperbaric chamber, the industry has appointed both a health and safety officer and a doctor specialising in hyperbaric and diving medicine. In furtherance of the PPA Code of Practice, divers adhere to strict diving profiles that greatly reduce the risk of decompression sickness. Dives shallower than 23 m last for no more than 40 minutes, followed by a stringent ascent and surface interval while the boat is repositioned for the next dive; dives in very shallow water (i.e. less than 8 m) can be longer. Time limits are strictly adhered to as extending the diving time by even a few minutes will significantly add to the total bottom time over a 10-dive day and increase the risk of decompression sickness. If dives

are conducted in deeper water they are for substantially shorter periods and many deeper pearl shell beds are not fished at all (Fletcher et al. 2006).



Figure 2.5. Pearl oyster fishing vessel (left) and diver (right)

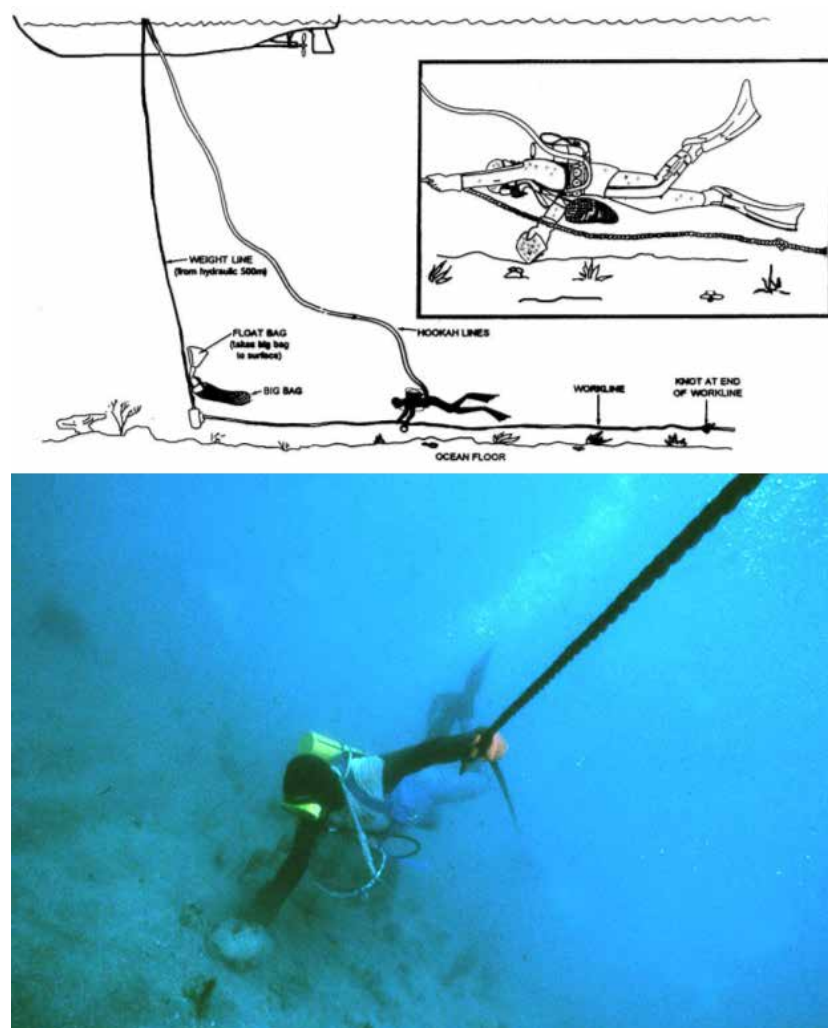


Figure 2.6. Schematic of pearl oyster diving operations (top) and photo of diver collecting a pearl oyster (bottom). Source: PPA 2008a

At the end of the dives, the pearl oysters that have been collected are recovered and graded. Shells that are too big or too small are returned immediately within the vicinity where they were taken. Pearl oysters of the target size are cleaned with a cleaver by scraping off encrusting organisms on the shell. A high-pressure hose is then used to wash the pearl oysters; no chemicals are used in the process. All treatments take place in the shade to prevent the pearl oysters from overheating. The pearl oysters are then placed in transport panels on the vessel that hold six to eight animals each, and every panel is individually tagged to indicate which company has collected the pearl oysters. The tags are numbered, and each company is only issued sufficient tags by the Department to match its quota. The transport panels are wire frames with plastic coating that hold two pearl oysters across and three down (Figure 2.7), although some operators use panels which hold eight pearl oysters. Light netting of about 2 mm diameter is used to hold the pearl oysters into place. Once they have been cleaned and placed in panels, they are kept in the shade and continuously rinsed with water. Pearl oysters are generally out of the water for less than an hour (Fletcher et al. 2006).



Figure 2.7. Panel containing pearl oysters. Source: PPA 2008a

Once all the pearl oysters have been placed in the frames, they are taken to a dump site (and are subsequently moved to the holding site) or holding site that are generally near the fishing grounds, where they are placed on the seabed in a marked area by divers for later usage. Transportation is in an open vessel, but the pearl oysters are kept under a shade cloth, and there is a padded covering on the floor of the vessel to minimise jarring. The sea floor at these sites is deliberately selected to be very similar to that found on the fishing grounds. Thus, they are mostly sand bottom with occasional sponges, soft corals, sea fans, and other fauna present, including some *Turbinaria* corals (Fletcher et al. 2006). At the holding site, the panels are attached at 900 mm intervals to lines, which may be several hundred metres long. Divers inspect the line on the bottom to ensure the pearl oysters are in the proper orientation (Wells & Jernakoff 2006).

Pearl oysters remain at holding sites for two to three months before they are transferred to the farm leases. This allows the pearl oysters to recuperate after the stress of being collected, transported and possibly having the nucleus inserted (Wells & Jernakoff 2006). During the late-1970s and early-1980s, serious mortality of pearl oysters occurred during the transportation phase. This mortality was attributed to the naturally-occurring bacterium *Vibrio harveyi*, which infected weak pearl oysters during transport (Wolf & Sprague 1978; Pass & Perkins 1985; Dybdahl & Pass 1985; Pass et al. 1987, 1988). As a result of this event a number of changes were made to improve the transport processes, including improved water circulation and long-line techniques that use a lower stocking density (Wells & Jernakoff 2006).

2.3.1.1 Catch and effort

Total catch in the POF since 1979 has oscillated between 330 000 and 830 000 oysters, with an overall average of 530 000 ($\pm 120\,000$ SD; Figure 2.8). The POF is primarily based on *P. maxima* stocks in Zone 2, which supplied 70 % of the total harvest in the past 30 years (Figure 2.3). In more recent years, the proportion of harvest coming from Zone 2 has been 100 % due to the cessation of fishing in Zone 1 and Zone 3 (Figure 2.8). The cessation of fishing in Zone 1 and Zone 3 was due to economic reasons, with industry either opting to use hatchery bred pearl oysters or obtain their pearl oysters from the Zone 2 fishery because of the more economical catch rates. In 2014, the pearling industry recommenced fishing in the buffer zone (area between Zone 1 and 2).

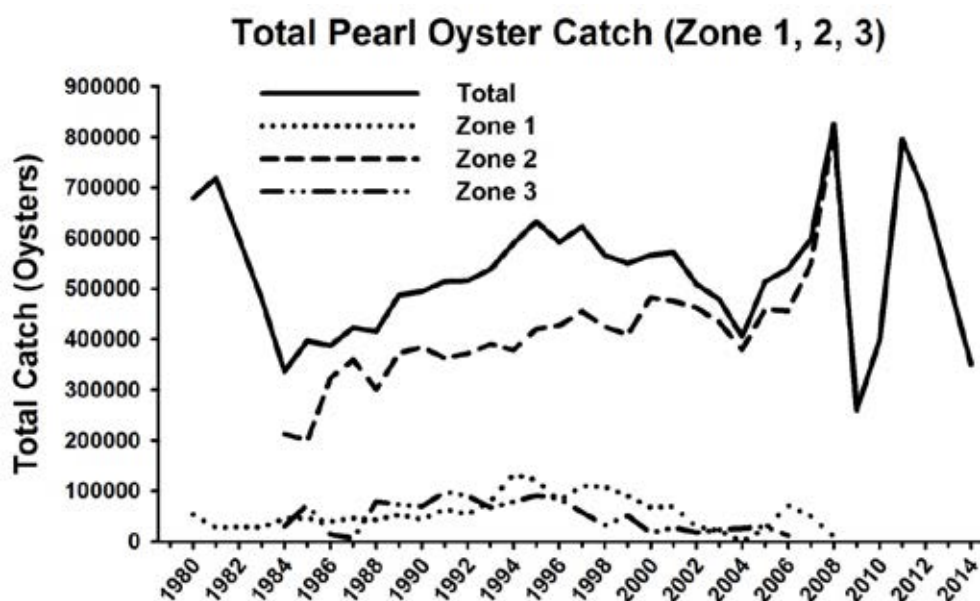


Figure 2.8. Total catch (in numbers) of *Pinctada maxima* from the POF and catch by management zone (see Figure 2.3 for spatial boundaries).

The POF has been managed via a maximum catch limit (TAC) since 1982. Over that period the TAC was only exceeded in the first year (1982), and catch has been at a very high percentage of the TAC in most years (Figure 2.9). In more recent years the TAC was not caught for two reasons. The global financial crisis (GFC) which began in 2008 resulted in a substantial reduction in pearling activities in 2009 and only a minimal harvest was taken (Figure 2.9). From 2009 to 2012 a very high abundance of pearl oysters, caused by an

exceptional year of settlement in 2005, resulted in stock abundance well in excess of both the fleet's fishing capacity, and the capacity of the markets to sustain the extra production of pearls that would have arisen if the 2005 cohort had been fully harvested (see Section 7.4.2.5.3).

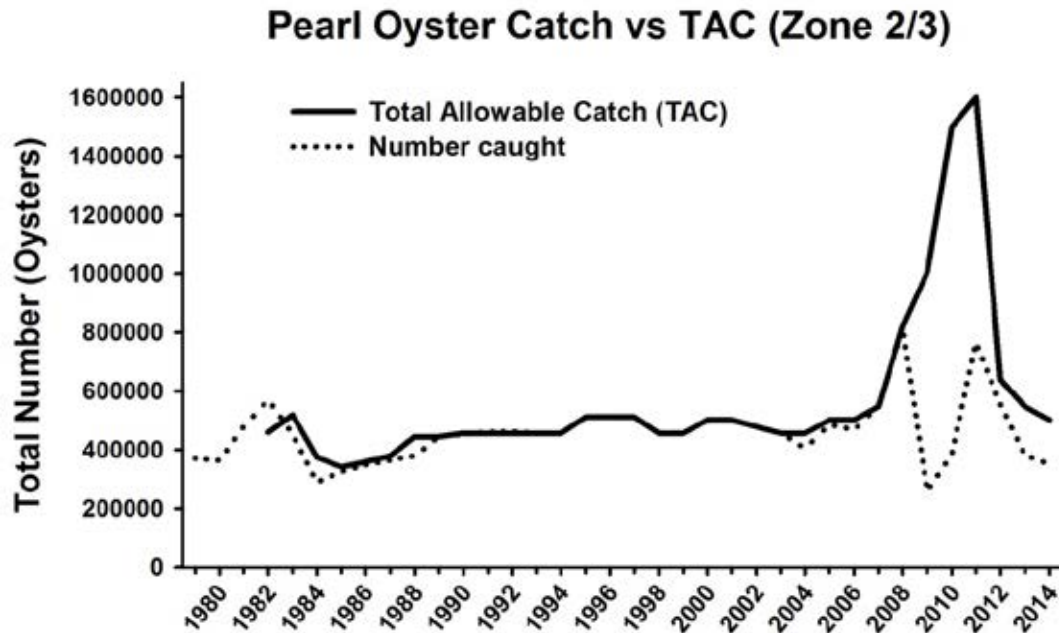


Figure 2.9. Total catch (in numbers) of *Pinctada maxima* compared with the TAC for the Zone 2 and Zone 3 management zones (see Figure 2.3 for spatial boundaries). Numbers refer to “culture shell” only and 2014 data is incomplete.

Total effort in Zone 2/3 since 1979 has oscillated between 3000 and 23 000 dive hours, with an overall average of 14 400 (± 4000 SD; Figure 2.10).



Figure 2.10. Total nominal effort (dive hours) in the Zone 2/3 Pearl Oyster Fishery between 1979 and 2014. Note – 2014 data incomplete at time of writing.

2.3.2 Cultivation

2.3.2.1 Hatchery component

Hatchery techniques for *P. maxima* are a relatively recent development and were pioneered by Rose & Baker (1994). In 1996, the WA Government granted hatchery options to licensees enabling production of pearls from hatchery-reared pearl oysters and reducing the reliance on the wild stocks of pearl oysters. Hatchery bred pearl oysters are now a significant component of pearl production in WA (Ministerial Policy Guidelines No. 17, DoF 2001).

After carefully selected broodstock complete spawning, fertilised eggs are stocked into tanks of filtered seawater. After approximately 24 hours, metamorphosis from egg to free-swimming larvae is complete, and cultured microalgae are added to the rearing tanks. Initial algal species used include *Chaetoceros calcitrans*, *C. muelleri*, *Tahitian Isochrysis* sp. (T. Iso), *Tetraselmis* sp., *Nannochloris* sp. (Rose & Baker 1994), *Pavlova lutheri* (Minaur 1969; Tanaka & Kumeta 1981), *I. galbana*, *C. calcitrans* and *Chlamydomonas* sp. (Nugrand et al. 1998). Gentle aeration is supplied to mix the suspension within the tank. Algal concentrations are increased during the culture period from 5 cells μl^{-1} on day one to 50 cells μl^{-1} on day 21 (Rose et al. 1990). Water changes are conducted every two to four days, at which time culling and size grading of the larvae also takes place (PPA 2008a).

Larvae begin to metamorphose into spat (juvenile pearl oysters; Figure 2.11) on day 24. A settling density of 1 larva per ml in the settling tanks is recommended by Taylor et al. (1998) to maximise yield. Settlement occurs either on the tank walls and bottom or on collectors hung inside the tanks. The former method allows more accurate counting when the spat are removed for re-settling, while the latter method requires less handling of newly settled spat. Spat attach to settling substrates with byssal threads as in the wild, and a variety of collectors have been used such as shade cloth, nylon netting, unravelled nylon rope and plates of dark coloured glass or plastic (Rose 1990).



Figure 2.11. Pearl oyster spat. Source: PPA 2008a

In the hatchery, newly settled spat are treated in a similar manner to larvae. As they become larger, the feeding rates and water circulation are increased to ensure that attached spat have sufficient access to food and oxygen. Larger spat may consume considerable amounts of algae, and this is when the algal production resources of the hatchery may be limiting. See

Mills (2000) for optimum temperature and feeding condition for the nursery culture of *P. maxima* spat.

Spat are commonly held in the hatchery until they are large enough to be placed into mesh cages or other structures. Once spat attain about 20 to 50 mm in shell length (SL), they are generally transferred onto small mesh panels on surface longlines and placed on farm leases (nursery sites). As the size of spat increases, they are transferred to panels with progressively larger mesh size (PPA 2008a).

Based on the results of Taylor et al. (1997) and Mills (2004), the spat is cleaned at approximately four week intervals. Given that the nursery period before the spat grow out to a seedable size (that can be utilised for pearl production) is two to three years, the efficiency and effectiveness of the farm cleaning program is optimised in order to reduce the considerable costs and infrastructure involved. Most farms now have personnel specialising in the maintenance of the spat to seeding size (PPA 2008a).

The *Pearl Oyster Translocation Protocol* (Appendix A) reflects the current legislation and outlines the required protocols that must be adhered to by commercial hatcheries. These protocols include annual inspection to authorise minimum standards for filtration of incoming seawater, cleaning and disinfecting procedures, health testing, sterilisation of effluent seawater and record keeping. Similar protocols for the translocation and health testing of pearl oysters are also in place in the NT.

2.3.2.2 Seeding

Cultured pearls are produced by placing an inert foreign object (referred to as a ‘nucleus’) into a pearl oyster. The pearl oyster secretes shell material that seals the nucleus completely from the remainder of the body, and over time, the animal continues to add layers over the pearl, enlarging it.

Seeding of the pearl oysters is undertaken during winter months (June – August), when water temperatures are lower and variation in temperature is minimal. Pearl oysters from the POF are seeded at either the holding sites or at the farm leases (depending on company preference), while those from hatchery-produced stocks are seeded on nearby farm leases and may then be moved, depending on the preferred location on the farm for pearl production. The surgical instruments used are sterilised before use according to a strict protocol developed by PPA. This practice is intended to minimise the risk of spreading disease between individual pearl oysters as they are seeded.

When they are to be seeded, the pearl oysters are recovered from the holding areas, and a piece of mantle tissues from another animal is inserted into the host oyster gonad, along with the nucleus of the pearl (Figure 2.12). The inserted mantle tissue becomes part of the host oyster’s tissues, creating a sac around the nucleus. If the oyster is subsequently used to produce a second pearl, the same sac is used (Joll 1996). After the nucleus is inserted, the animals are returned to the ocean in panels at the holding area (on the holding site or farm lease). After an initial recovery period of 7 – 8 days, the pearl oyster panels are turned by

divers every 2 – 5 days. This helps develop the sac around the nucleus and prevents the nucleus from breaking out of the tissue. Pearl oysters are x-rayed after 4 – 6 months to determine if the nucleus has been retained and the pearl has started to grow (Wells & Jernakoff 2006). If the nucleus has been rejected, the animal is operated on again the following year or replaced with a hatchery shell (Scoones 1991; Joll 1996).



Figure 2.12. Seeding of pearl oyster. Source: PPA 2008a

Following the seeding and post-operative phase, all pearl oysters are placed into panels ready for transportation to the ‘grow out’ phase on the farm lease. Panels consist of a steel frame supporting plastic mesh which has pockets to accommodate individual pearl oysters (PPA 2008a).

2.3.2.3 Transportation

Pearl oysters are transported by vessels from the dump site/ holding site to the pearl farms. All pearl oysters must be cleared from the holding site by 31 December each year. During transportation, the pearl oysters are maintained in running seawater in holding tanks on the vessel. No feeding or chemicals are used in this process. Each vessel is capable of transporting 20 000 – 25 000 animals on a single trip (Wells & Jernakoff 2006).

The *Pearl Oyster Translocation Protocol* (Appendix A) reflects legislative requirements, health sampling procedures and certification approval required prior to the movement of any pearl oysters in WA and into / out of WA.

2.3.2.4 Pearl oyster farm leases

Farm leases are located between Arnhem Land in the NT and Exmouth in WA, although the majority of farming activities occur in the remote Kimberley region of northern WA (see Figure 2.3). The Kimberley region is a very high-energy environment, with tidal amplitudes up to 10 m, which generate strong tidal currents. These currents constantly renew the

phytoplankton, which nourish the pearl oysters and reduce the potential for localised impacts from farm leases. Some farms, such as Kuri Bay, Cygnet Bay and Knocker Bay, have been in constant pearl production for over 50 years (PPA 2008a). Farm leases are separated from each other, usually by 5 nm to counter disease; however, if a holder of an existing farm lease agrees, a new farm may be established within 5 nm of an existing farm lease. If the farm lease is owned by the same legal entity a new pearl oyster farm lease may be established within 2 nm (DoF 1998).

The process of obtaining farm leases for pearling is outlined in the Ministerial Policy Guideline 8 (see Section 2.4.1.2.2). The total area of pearl oyster farm leases in WA in 2014 was 645 km² (188 nm²) and in 2015 was 640 km² (186 nm²). The majority of farm leases occur in waters of less than 30 m depth, and no farm leases are located in waters deeper than 40 m depth.

Pearl oyster farm leases are non-exclusive, meaning there is no impediment to recreational or commercial vessels traversing the farm lease or using the area for fishing or other recreational activities. Farm leases are chosen according to their protection from cyclones and the sediment characteristics for pearl production. Favoured farm lease areas are removed from pollution sources and other threats to water quality, as poor water quality can lead to mortalities and reduced pearl size and quality. Freshwater is also avoided when selecting a farm lease, with sites located well away from large river mouths that are prone to flooding during the wet season (PPA 2008a).

Mud-bottom areas are preferred, as mud provides the best holding ground for the longline anchor system. Estuarine areas and submerged reef area avoided as they act as reservoirs for problematic fouling organisms such as barnacles and oysters (from estuarine areas) and pathogens, such as *Cliona* (from reef areas; PPA 2008a).

2.3.2.5 Pearl farming

Pearl oysters in the panels are removed from the holding tanks on the vessel at the farm lease, where they are placed in panels in the ocean for two years to allow the pearls to grow. As Australian producers cannot compete with the low production costs of many of their competitors, high quality standards are used to differentiate and maintain the premium paid for Australian pearls.

On delivery to the farm lease, the panel of seeded pearl oysters are placed onto surface longlines consisting of a rope backbone with attached surface floats anchored at each end in the thick mud bottom by specially-designed anchors (up to 2 m deep). Panels are attached to longlines by short lengths of rope ('droppers') at regular intervals. Vertical lines with panels containing pearl oysters are hung from the buoys and are maintained well off the bottom to avoid fouling. The lines are at least 100 m offshore and are 20 – 30 m apart to avoid entanglement if one line breaks. An average line is 100 m long, with panels every metre for a total of 600 pearl oysters per line. The use of surface longlines has the advantages of avoiding the use of divers, minimising interactions with saltwater crocodiles and allowing the use of less-skilled workers for routine work (Wells & Jernakoff 2006; PPA 2008a).

Pearl quality is linked to the health and growth of the pearl oyster, which can be maximised by maintaining adequate quantities of food and nutrients. To ensure maximum food access, the pearl oysters are cleaned regularly to remove biofouling organisms, which compete for available food. Pearl oysters are removed from the water and mechanically cleaned every 4 – 5 weeks, or more frequently in the wet season when growth of fouling organisms is faster (Wells & Jernakoff 2006; PPA 2008a).

Farm employees conduct cleaning aboard specially-designed cleaning vessels. During cleaning, the longline is lifted onto large winches on the side of the cleaning vessel that pulls the vessel down the length of the longline (Figure 2.13). As a panel comes along the line, it is pulled to the surface and placed inside a cleaning machine that sprays the pearl oysters with high-pressure seawater as it moves along the conveyor belt. The seawater removes the bulk of the fouling (which consists of slime, mud and invertebrates) from the panels and pearl oysters. Hard fouling organisms, such as barnacles, are then removed by cleaning staff using stainless steel chisels. The cleaned panel is then returned to the water having never been detached from the longline. No chemicals are used in the cleaning process (PPA 2008a).



Figure 2.13. Typical cleaning boat attached to a pearl longline (top) and a ‘panel’ of oysters being returned to the sea after cleaning and inspection on-board the vessel (bottom). Source: PPA 2008a, J. Andrews 2014

2.3.2.6 Pearl harvest

The temperature of the surrounding seawater has an important effect on the lustre and colour of the pearl, and pearls are generally harvested during winter in July and August (Scoones 1991). Similar to seeding, harvesting is conducted on specially-designed vessels on the farm leases or at a shore-based facility. Panels of seeded pearl oysters are delivered to the harvest vessel / land site where the oysters are opened and presented to technicians, who surgically remove the pearl from the sac (PPA 2008a).

If the quality of the pearl is judged to be appropriate and the pearl oyster is in good condition, a new nucleus is inserted into the pearl sac. As the pearl sac is already in place from the first seeding process two years previous, the insertion of a new piece of mantle tissue is not required. Following the pearl removal and reseeded, the pearl oyster is placed back into a panel and returned to the water attached to the longline. Over the next two years, the pearl production process is repeated. At harvest, an assessment is made as to whether another nucleus may be inserted to produce a third pearl from an individual pearl oyster (PPA 2008a). As many pearl oysters as possible are reseeded; approximately 40 – 50 % of the pearl oysters can be used a second time, and 40 – 50 % of these can be reused a third time (Wells & Jernakoff 2006).

Pearl oysters that have not produced a pearl of sufficient quality are not reseeded and are processed to produce saleable end products, such as pearl oyster meat and MOP. Only the adductor muscle is utilised for pearl oyster meat, and it is snap frozen on-board the harvest vessel. The MOP is graded according to international quality requirements and packaged into storage drums (PPA 2008a).

2.4 Management arrangements

An overview of the fishery-specific governance and management relating to the pearling industry is presented below. More detailed information, including a description of the long- and short-term management objectives for the pearling industry, is provided in the MSC Principle 3 Sections 15 and 16.

Management of the pearling industry is based on the following:

- **Species restrictions:** The pearling industry is limited to the collection, seeding and grow-out of *P. maxima* only under the *Pearling Act 1990* (PA);
- **Size Limits:** The minimum size limit for the collection of wild pearl oysters is 120 mm SL² (3 – 4 year old animals). There is also a legal maximum size limit of 160 mm SL in place for pearl oysters in the Exmouth Gulf.

² Note the harvest of pearl oysters between 100 and 119 mm SL was approved in 2011 for an initial three years, and was extended for another three years at the end 2013 (until the end of 2016). This approval was subject to the harvest level of pearl oysters of this size being less than 15 % of the TAC.

- **Zone restrictions:** The WA pearling industry is separated into four zones (Figure 2.3) in order to manage wild pearl oyster stocks and translocation issues. The Zones are:
 - **Zone 1:** extends from the Northwest Cape (including Exmouth Gulf) to 119° 30' E longitude and includes 115 wildstock quota units. There are 5 wildstock licences in Zone 1;
 - **Zone 2:** extends east of Cape Thouin (118° 10' E) and south of 18° 14' S and includes 425 wildstock quota units. There are 9 wildstock licences in Zone 2; these licensees also have full access to Zone 3.
 - **Zone 3:** extends west of 125° 20' E and north of 18° 14' S and includes 32 wildstock quota units. There are two wildstock licence holders in Zone 3; these licence holders have access to Zone 2.
 - **Zone 4:** extends east of 125° 20' E to WA/Northern Territory border; although all licensees have access to this Zone, no fishing occurs in Zone 4; however, pearl farming does occur in this Zone.
- **Quota system:** The POF is managed through output controls in the form of a total allowable catch (TAC), which is divided into individually-transferable quotas. There are 572 total quota units, allocated between 15 wildstock licences across management Zones 1 – 3. The value of these quota units varies depending on the status of pearl stocks and the annual TAC (as set by the CEO of the Department, based on advice from the Pearling Stock Assessment Working Group [SAWG], the PPA and the Department).

Each operator has an annual quota of pearl oysters, which is given as licence conditions that establish a number of quota units (on each licence). The 2015 TAC and associated quota unit values were as follows (see Section 16.2.1 for information on stock assessment outcomes related to TAC setting advice):

- **Zone 1:** TAC of 54 970 pearl oysters, which equates to 478 pearl oysters per unit;
- **Zones 2/3:** TAC of 612 380 pearl oysters, which equated to 1340 pearl oysters per unit (within the TAC there was an agreement that 502 700 pearl oysters between 100 – 175 mm SL could be taken, equating to 1100 pearl oysters per unit; and 109 680 pearl oysters greater than 175 mm SL could be taken, equating to 240 pearl oysters per unit);
- **Total 2015 TAC:** 667 350 pearl oysters.

Companies producing hatchery-reared pearl oysters must hold the appropriate hatchery licences and relevant seeding quota to seed the pearl oysters. The impacts from hatchery activities are managed primarily through the spatial separation of most of the farm leases from the main wild stock fishing areas. Hatchery activities primarily occur in Zone 4 and the NT, while fishing activities are focused on Zones 2/3. Other important management controls include:

- A limit on hatchery produced oysters (that can be seeded each year (enforced by quota licence conditions and compliance monitoring);

- The use of WA-origin, wildstock pearl oysters for all hatchery broodstock (i.e. broodstock must be taken from Zone 1, 2 or 3 of the POF or produced in that hatchery); and Legislation that controls the movement of pearl oysters into WA.

2.4.1 Legislation and policy

The PA provides the overarching legislative framework to implement the management arrangements for the pearling industry. The key object of the PA is to regulate pearling and hatchery activities and to provide for the conservation and management of the *P. maxima* resource. The PA and the *Pearling (General) Regulations 1991* (PR), together with subsidiary instruments that include regulatory notices, Ministerial Policy Guidelines, leases, licences and licence conditions, provide power for the management of all aspects of the pearling industry, including wild collection, hatchery and grow-out aspects.

Licence holders and fishers must also comply with the requirements of the:

- Western Australian *Fish Resources Management Act 1994* (Part 3 and Division 1 of Part 11);
- Western Australian *Fish Resources Management Regulations 1995* (Part 13A);
- *Western Australian Marine Act 1982*;
- Western Australian *Wildlife Conservation Act 1950*;
- Western Australian *Conservation and Land Management Act 1984*;
- Western Australian *Environmental Protection Act 1986*; and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC).
- Any other legislation governing the use of the marine environment in which activities occur.

It should be noted that the pearling legislation and management arrangements are currently being reviewed to transition into the Aquatic Resource Management Act (currently before Parliament as the *Aquatic Resource Management Bill 2015*); however, no significant changes to the management regime are anticipated as part of this process. The Aquatic Resource Management Act (ARMA) will repeal the *Pearling Act 1990*.

There is a Memorandum of Understanding (MoU) in place between the WA Minister for Fisheries and NT Minister for Primary Industry and Fisheries regarding the management of the *P. maxima* industry (Appendix B). This MoU has been developed (1) to ensure that consistent standards of management and compliance exist within the WA and NT pearling industry; and (2) to ensure that efficiencies and synergies in pearling management and compliance are achieved through cooperative arrangements.

2.4.1.1 Pearling Act 1990 and Pearling (General) Regulations 1991

The PA provides the overarching legislative framework to implement the management arrangements for the pearling industry, including the cultivation of pearls, hatchery

production of pearl oysters, a form of individual transferrable fishing rights, and other provisions relating to issues such as diver safety. This includes providing the CEO of the Department power to grant farm leases, licences and permits (under Section 23), subject to conditions being satisfied and having regard to *Ministerial Policy Guideline No. 8* and *17* (see below).

The PR supports the PA by providing a framework for the management of administrative and technical matters.

2.4.1.2 Subsidiary instruments

2.4.1.2.1 Notices

Regulatory notices in place under the *Pearling Act 1990* include the:

- *Pearling (Declaration of Pearl Oysters) Notice 1995*, which limits the collection, seeding and grow-out by the pearling industry managed under the PA to *P. maxima* only;
- *Pearling (Pearl Oyster Shell Size) Notice 1997*, which sets any minimum and maximum legal sizes for *P. maxima*; and the
- *Pearling (Declaration of Zones) Notice 1995* and *Pearling (Declaration of Zones) Amendment Notice 1997*, which outline the boundaries of the Zones within the POF (Figure 2.3).

2.4.1.2.2 Ministerial Policy Guidelines

Ministerial Policy Guidelines (MPGs) Nos. 8 and *17* were issued pursuant to Section 24 of the *Pearling Act 1990*. These guidelines establish the policies that direct consultation with and management of the pearling industry.

2.4.1.2.2.1 MPG No. 8

MPG No. 8³ summarises the process of obtaining a farm lease for an area of coastal water for pearling, outlines the process required for farm lease applications (including public and inter-departmental consultation) and explains the requirements for site environmental impact assessment. The appeals process is also outlined. MPG No. 8 also includes applications for aquaculture leases (under the FRMA), providing for a single, proactive planning and application procedure for both industries, which involves wider community consultation so that issues of concern can be addressed in the early stages and any environmental issues identified and resolved before applications reach an advanced stage.

2.4.1.2.2.2 MPG No. 17

MPG No. 17 outlines a number of guidelines on significant matters that may affect farm leases, licences and permits, including:

- General outcomes to be achieved for the pearling industry;

³ http://www.fish.wa.gov.au/Documents/ministerial_policy_guidelines/fmpg008.pdf

- The zones of the POF;
- Quota allocations (both wildstock and hatchery quota) and the transfer of quota;
- The capture of pearl oysters for research purposes;
- Distances between farm leases (including new authorisations, expansion and transfers) and holding areas;
- The utilisation of farm leases (i.e. formulae for calculating lease area requirements based on quota and stock);
- The development of hatcheries and hatchery quota;
- The translocation of pearl oysters and establishment of quarantine sites;
- Foreign investment; and
- A Diving Code of Practice to ensure safe diving activities.

Establishing Pearl Farm Leases and Holding Sites

Farm leases are issued under Section 23 of the PA, with regard to MPG Nos. 8 and 17. The maximum farm lease term under the PA is 21 years, with MPG No. 17 suggesting a 21+ year term.

The pearling industry holds strongly to the view that guidelines regarding the distance between farm leases and holding sites should apply. This view arose from a problem with pearl oyster mortality, which industry believed could have been transmitted from one farm lease to another. Additionally these guidelines are for commercial security and the opportunity for expansion (DoF 2001). The pearling industry accepted that the distance factor could be reduced if there was agreement between the licensees to be affected, farm leases were owned by the same legal entity or if there was a clear physical geographic division between farm leases. Accordingly, guidelines were established in relation to the issue of new farm leases, the expansion of a current farm lease and the transfer of a farm lease. A summary of these guidelines is provided below; see MPG No. 17 for more details.

1. Grant of a new authorisation:

- New farm leases must be a minimum of 5 nm from any part of the boundary of any pre-existing farm lease, unless the holder of the pre-existing farm lease provides written consent to the application. .
- Applications for sites within 2 nm of an existing farm site will be refused (regardless of consent from pre-existing lease holder) unless the application is made by the same legal entity holding the existing authorisation.

2. Expansion:

- A pre-existing farm lease within 5 nm of another more-recently granted farm lease has the right to expand within the 5 nm zone; however, it cannot expand closer than 2 nm to the newer farm lease boundaries.

- Where existing farm leases are already separated by less than 2 nm (i.e. were issued prior to MPG No. 17), no expansion which further reduces the distance between the farm leases is permitted, except where the farm leases are held by the same legal entity.

3. Transfers:

- A farm lease holder may transfer an authorisation to a second legal entity already holding a pre-existing authorisation, with specific requirements outlines depending on the distance between the two authorisations.

Some companies within the pearling industry will also dump and/or hold and seed pearl oysters near the pearling fishing grounds during each year prior to transferring the pearl oysters to farm leases. It is important that the dump and holding sites of any one licensee be clearly separated from that of any other dump and holding sites and also from any other farm lease. Accordingly, the following guidelines have been established in relation to the approval of new holding sites:

1. The proposed boundaries must be more than 2 nm of the nearest boundary of any other holding site or more than 5 nm of any farm lease, unless there is mutual consent between the applicant and the pearling licensee of the pre-existing holding site;
2. The company making the application must not have an approved holding site within 20 nm of the holding area being sought; and
3. The total area of the proposed holding site must not exceed 4 nm² (DoF 2001).

In addition, there is an onus on the company operating a holding site to minimise the impact that its use as a holding site may have on the collection of pearl oysters from the wild.

Dump sites are used on a temporary basis only. A site is to be utilised in line with Part 5 of the PR, with a dump record log sheet (Regulation 15 of the PR) to be completed and are required to be marked with surface buoys.

Utilisation of Pearl Oyster Farm Leases

In considering farm lease applications, the CEO (who delegated power to Director, Aquatic Management on 23 November 2011) of the Department takes into account the requirements of the application to secure an additional farm lease. Under MPG 17 an applicant should not be granted an additional farm lease if it is considered to be in excess of their requirements based on an industry-agreed formula of quota holding or stock holding to lease area.

$$\text{Farm Lease Area Entitlement (nm}^2\text{)} = \frac{\text{Quota}}{5900} \times \frac{1.25}{1.00} + 1.0$$

$$\text{Farm Lease Area Entitlement (nm}^2\text{)} = \frac{\text{Stock Holding}}{16250} \times \frac{1.25}{1.00} + 1.0$$

The formulas are based either on quota against 5900 pearl oysters or stock holding against 16250 pearl oysters; this figure is then multiplied by 1.25 to allow for factors such as stock rotation. In addition, the provision of one square nautical mile is made for the use of hatchery operations. ‘Quota’ includes both wildstock and hatchery quota and ‘stock holding’ includes seeded wildstock, seeded hatchery options and seeded hatchery quota. Note that given the dynamic nature of marine planning and access to farm leases, issues concerning the utilisation of farm leases will continue to develop and, as such, the current guidelines and formulae are subject to review through the usual consultation process with industry (DoF 2001).

Hatcheries

MPG No. 17 provides a mechanism for the pearling industry to obtain pearl oysters by the grow-out of young pearl oysters (spat) collected from the wild and the grow-out of pearl oysters cultured in a hatchery and established guidelines for the development of hatcheries and spat collection technology and quota.

Translocation of Pearl Oysters and Quarantine Sites

The movement of pearl oysters is regulated by Regulation 42 of the *Pearling (General) Regulations 1991* and Part 13A of the FRMR. Detailed guidelines on the translocation of pearl oysters are outlined in the *Pearl Oyster Translocation Protocol*. The protocol reflects the legislation and provides guidance on:

- The movement of hatchery-produced pearl oysters;
- The movement of all pearl oysters between farm lease areas⁴;
- The reporting of hatchery-settled pearl oyster spat (via a *Pearl Oyster Settlement Form P9*);
- The requirements for spat leaving a hatchery and the testing of hatchery spat by a fish pathologist;
- The requirements for pearl oyster spat transported from a hatchery to a farm lease site (including submission of required log sheets);
- The translocation and handling procedures when unusually high mortality levels indicate there may be a disease risk;
- The requirements and procedures for health testing and the destruction of pearl oyster spat that has failed health testing; and
- The minimum standards required for hatchery accreditation, including the cleaning/disinfecting schedule and the disinfection of hatcheries when a batch fails health certification.

⁴ Note the *Pearl Oyster Translocation Protocol* does not apply to the initial movement of wildstock pearl oysters sourced from the fishing beds within WA to a dump site/holding site within WA. However pearling activity and transport approvals under the PA are still required.

The *Pearl Oyster Translocation Protocol* also reflects the hatchery requirements under the *WA Pearling Act 1990*, the *WA Pearling (General) Regulations 1991* and FRMR (Part 13A), as well as additional protocols for commercial pearl oyster hatcheries in WA. This includes annual inspections to authorise minimum standards for filtration of incoming seawater, cleaning and disinfecting procedures, health testing, sterilisation of effluent seawater and record keeping. Similar legislation and protocols for the translocation and health testing of pearl oysters are also in place in the NT.

Additionally, there are a number of criteria for establishing a quarantine site for translocated hatchery-produced pearl oysters due to the potential for these pearl oysters to carry pathogens (see Part 7C of the PR and MGP No. 17 for details).

2.4.1.2.3 Licences, leases and permits

The CEO (who delegated power to Director, Aquatic Management on 23 November 2011) may grant pearling leases, licences and permits under Section 23 of the *Pearling Act 1990*, subject to a number of conditions being satisfied and the CEO having regard to any MPGs issued. There are currently no permits issued under the PA.

A summary of the primary licence types and their related activities is provided in Table 2.1. For examples of each licence type, see Appendix C. Operators are also required to hold a Pearl Boat Licence, Pearl Masters Licence and / or Pearl Divers Licence, where relevant.

Table 2.1. Primary licence types issued under Section 23 of the *Pearling Act 1990* in relation to the WA pearling industry

Licence Type	Quota Listing	Renewal	Current No. of Licences	Related Activities	General Conditions
Pearling (Wildstock) Licence	Wildstock Quota (wildstock fishing, wildstock 'other'; and pearl production quality supplement ¹ by Zone)	Annually	15	Required to collect pearl oysters from the wild (as part of quota from specified Zones), including: <ul style="list-style-type: none"> • Taking or attempting to take pearl oysters from the wild; • Removing or attempting to remove pearls from wildstock pearl oysters; • Moving, dumping, holding, storing or transporting wildstock pearl oysters; • Practising, or attempting to practice, pearl culture techniques on wildstock pearl oysters. 	None
Pearling (Seeding) Licence	Hatchery Quota (seeding and pearl production quality supplement)	Annually	13	Required to carry out seeding or associated activities on hatchery quota, including: <ul style="list-style-type: none"> • Seeding operations on hatchery quota pearl oysters; • Moving, dumping, storing or transporting hatchery quota pearl oysters; • Practising pearl culture techniques on hatchery quota pearl oysters; and • Removing (or attempting to remove) pearls from such pearl oysters. 	All pearl oysters seeded under this licence (or an equivalent number of pearl oysters seeded under a Pearling [Wildstock] Licence), must be transported into the Northern Territory by 31 December each year. The licence holder must advise the Department if the number of seeded pearl oysters being transported to the NT is less than the number able to be seeded under the listed quota.
Pearl Oyster Hatchery Licence (For Propagation)	No	Annually	2	Generally issued as standalone licence for propagation of spat and defines a land-based site at which the activity can take place. Permitted hatchery activities include: <ul style="list-style-type: none"> • Producing stocks of pearl oysters by acclimatization, propagation, hatching, breeding, rearing or raising or attempting to do so; and • Moving, dumping, holding storing or transporting pearl oysters or pearl oyster spat for the purposes of the above. 	These licences do not authorise seeding operations on any pearl oyster.

Pearl Oyster Hatchery (Nursery) Licence	No	Annually	8	<p>Required to carry out hatchery activities, including:</p> <ul style="list-style-type: none"> • Grow out of spat on a nursery site; • Spat collection; and • Moving, dumping, holding, storing or transporting of pearl oysters or pearl oyster spat for the purposes of grow out or spat collection. 	<p>These licences do not authorise seeding operations on any pearl oyster.</p> <p>Pearl oysters or pearl oyster spat shall only be sold by the licensee to the holder of a pearling licence.</p>
Pearl Oyster Hatchery Licence (including Hatchery [Nursery Licence])	No	Annually	5	<p>This licence is a combination of the two licence types above and is issued to a licensee when they wish to propagate and grow out spat. This licence type defines a land-based location at which the 'permitted hatchery activities' can be carried out.</p> <p>Permitted hatchery activities include (as printed on each licence):</p> <ul style="list-style-type: none"> • Propagation: <ul style="list-style-type: none"> • Producing stocks of pearl oysters by acclimatization, propagation, hatching, breeding, rearing or raising or attempting to do so; and • Moving, dumping, holding, storing or transporting pearl oysters or spat for the purpose of the above. • Grow-out: <ul style="list-style-type: none"> • The grow out, on a nursery site, of spat; • Moving, dumping, holding, storing or transporting pearl oysters or spat for the purpose of the above. • Spat Collection and moving, dumping, holding, storing or transporting spat for these purposes. 	<p>These licences do not authorise seeding operations on any pearl oyster.</p>

¹Wildstock 'other' and pearl production quality supplement quota under *Pearling (Wildstock) Licences* is aligned to licence for seeding purposes only, not capture.

Farm leases (see example in Appendix D) provide a description of the leased area to be used by the lessee (must be holder of a licence under the *Pearling Act 1990*) for the purposes of conducting pearling activities of the type specified in that licence for a specific period. Farm leases are subject to a number of conditions, including:

- The lease does not confer exclusive use of the waters by the lessee in respect of purposes other than hatchery or pearling activities permitted under the pearling or hatchery licence held by the lessee;
- Access shall be maintained through and within the farm lease at all times for other legitimate uses, including native title holders;
- The farm lease shall be marked (as outlined in the *Guidance Statement for Evaluating and Determining Categories of Marking and Lighting for Aquaculture and Pearling Leases/Licences 2010*¹);
- Any flotation buoys used on the longlines must be purpose built, securely attached to the lines and black in colour, or as otherwise approved by the Department;
- No anchors and bottom structures shall be placed on, or within swinging distance of, corals and seagrass beds;
- The lessee shall undertake monitoring of the benthic habitat at the farm lease and any deleterious impacts shall be reported to Department of Parks and Wildlife (DPaW);
- Any injury or entanglement to rare or protected fauna that occurs within the lease area shall be reported immediately to DPaW;
- The lessee shall not deposit any rubbish or permit any rubbish or discarded equipment to remain on site, nor dispose of any rubbish or discarded equipment at sea or on adjacent beaches;
- The lessee shall bait for rodents at all times on all vessels associated with the pearling operations; and
- On decommissioning, all operational equipment and associated infrastructure must be removed from the site (note this condition is not listed on all lease instruments).

2.4.2 Industry initiatives

2.4.2.1 Pearling Environmental Code of Conduct

Both the NT and WA pearling industries have adopted a *Pearling Environmental Code of Conduct* (PPA 2008a), which outlines environmental responsibilities of license holders and individuals operating within the pearling industry. The Code of Conduct evolved out of a continuing consultation process involving representatives from the pearling industry, government, environmental interest groups, recreational fishers, Aboriginal groups and other stakeholders with a commitment to the sustainable management of WA's aquatic environment. The Code is administered and revisions coordinated through the PPA.

The Code stipulates that the pearling industry will work in conjunction with government and other stakeholders to ensure that it is managed sustainably (ecologically and economically)

¹ http://www.fish.wa.gov.au/Documents/aquaculture_licencing/markings_and_lighting_guidance_statement.pdf

and that the social, economic and environmental benefits are maintained. The guiding principles of the Code provide specific sectors of the industry with a framework for the development of individual company Environmental Management Systems (EMS), which focus on the ecological and economic sustainability of their particular site or operation. A copy of the Code is available online (PPA 2008a¹).

The Code includes a number of activities to protect the environment in which the pearling industry operates, including:

- Encouraging the development and operations of pearling at a rate in accordance with ecologically-sustainable principles;
- Encouraging the development and operations of pearling in accordance with legislative responsibilities and environmental standards;
- Supporting natural resources management that provides improved outcomes for sustainable resource use (both wildstock and marine leases) through effective cooperation between government agencies, the pearling industry and the wider community;
- Promoting pearling industry training and education opportunities in environmental awareness, aquatic bird species identification, clean production methods and best pearling practice;
- Recognising the importance of good farm lease selection, system design and infrastructure to minimise impacts;
- Monitoring and reviewing farm management practices to minimise ecological impacts on:
 - Sensitive benthic habitats, such as coral, seagrass and mangroves;
 - Marine wildlife, mammals and migratory bird species and their breeding, feeding and resting areas;
 - Estate islands through introduction of feral plants and animals;
- Minimising and, where practical, eliminating the use of chemicals;
- Providing for disposal and/or processing of wastes to minimise the risk of ecological damage;
- Working in close association with governments to maintain and continuously renew protocols regarding the translocation of live pearl products within and between states; and
- Supporting the maintenance of precise records regarding the transfer or translocation of pearl oysters between pearling operational areas.

2.4.2.2 Environmental management systems

In 2003, the PPA became one of two industry association partners in the National Heritage Trust funded Seafood Services Australia Ltd (SSA) pilot program for developing Environmental Management Systems (EMS). Through this project, SSA and the PPA worked

¹<http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix2.pdf>

closely with the MG Kailis Group to develop and implement a cost effective EMS template that could be generally implemented across the pearling industry.

2.4.2.3 Whale management policy and protocol

The *Whale Management Policy and Protocol* (PPA 2008b¹) was developed by PPA, in conjunction with the Department of Environment and Conservation (now the WA Department of Parks and Wildlife, DPaW) and Seanet Environmental Extension Services, to establish a policy and response protocol to deal with a whale interaction in the rare event that one should occur. The *Whale Management Policy and Protocol* includes an overview of pearling industry instructions for preventing whale entanglements and interactions, an overview of local whale species and identification guides and a response protocol should an interaction or entanglement occur.

2.5 Risk assessments

Periodic risk assessments are used to assess the impact of the pearling industry activities on ecosystem components. Prior to 2015, risk assessments were conducted separately for cultivation of pearls and wild collection aspects; however, the most recent risk assessment (August 2015) incorporated all aspects of the pearling industry (and in some cases include the NT pearling industry), including wild collection, culture and hatchery production.

Risk assessments are generally scheduled to take place every five (5) years; however, they can be triggered following substantial change in fishing operations and/or management arrangements or following evidence (including anecdotal evidence) of changes in catch or other ecological impacts (e.g. number of ETP species interactions, habitat impacts), as these changes may indicate a significant change in the previous assessment's outcomes. For example, the impact of 'recreational take of specimen shells' was included in the 2013 wild collection risk assessment following anecdotal reports that this activity was occurring in the POF.

The risk ratings are reviewed by Departmental staff and reported annually in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher & Santoro 2014), which is available on the Department's website.

2.5.1 Cultivation of pearls

The environmental effects of the pearling industry were initially assessed by Enzer Marine Environmental Consulting (Enzer Marine Environmental Consulting 1998). As part of this study, an extensive literature search was undertaken to obtain information on the pearling industry and possible environmental impacts of it. The report concluded that '*in general, the industry was found to be environmentally benign, producing a high value produce with a minimum of environmental disruption*'. The report identified four potential environmental problems:

1. Antifoulant paints;
2. Materials used in the manufacturing of pearls;
3. Sanitation; and

¹<http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix4.pdf>

4. Plastic tags.

Other generic issues identified were associated with vessel and shore camp activities:

- Waste disposal;
- Grey water;
- Fuel and oil storage;
- Oil disposal; and
- Boat paints.

Following this study, in 2001, the PPA commissioned an environmental risk assessment consultancy (International Risk Consultants – Environment [IRCE]) to conduct an environmental audit and risk assessment of the pearling industry in WA, particularly focusing on the activities involved in the cultivation of pearls (Jernakoff 2002). Building on the Enzer report (discussed above), the consultants undertook:

- An Ecological Risk Assessment on pearl culture; and
- Environmental information and management gap analyses;

Following three site visits and discussions with the pearling industry, an environmental and ecological risk assessment workshop was conducted in September 2001 based on existing knowledge, considering all aspects of the pearling industry, identifying and prioritising gaps in knowledge and producing a set of prioritised risks. The workshop included pearling industry representatives, fisheries scientists and managers, staff from other regulatory agencies and community environmental representatives. The goal of the workshop was to document and rank the main potential environmental and ecological risks that arise from various activities carried out by the pearling industry (Wells & Jernakoff 2006).

At the workshop, participants were asked to list all sources of environmental problems that could potentially be caused by the pearling industry. These were then entered into a risk matrix of likelihood and consequence, with each ranked from 1 – 6. Multiplying the two scores together provided their position in the matrix. Scores of 20 and above were considered high concern, 7 – 19 were moderate and 6 or below were low (Wells & Jernakoff 2006). Thirteen environmental and ecological issues were identified across the pearling industry. No high risks were identified; 23 % were moderate risks and 77 % were low risks (Table 2.2).

A follow-up risk assessment workshop was held in September 2004 (PPA 2004), where the pearling industry's responses and progress relating to the issues highlighted in the 2001 risk assessment were presented. The workshop had 23 participants, including representatives from the Department, PPA, Conservation Council of WA, WA Museum, NT Dept. of Fisheries, Seafood Services Australia, University of NSW, University of Tasmania, Marine and Coastal Community Network, WAFIC and the Aboriginal Lands Trust, as well as pearling industry and company representatives. Similar to previous (2001) assessment, the 2004 workshop found the majority of environmental risks associated with the pearling industry were low, with only four issues considered a moderate risk (Table 2.2). Three new issues were also identified as part of the 2004 workshop:

- Fuel and chemical management;
- Water quality loss (from theoretical spills of diesel or aviation fuel and the chemical treatment of sewage); and
- Waste management on vessels.

Table 2.2. Risk ratings of impacts from pearl farm activities. Source: Wells & Jernakoff 2006; PPA 2004.

Impacts from Pearl Farm Activities	2001 Rating	Impacts from Pearl Farm Activities	2004 Rating
Introduction of disease from translocation	LOW	Introduction of disease from hatchery	LOW
Introduction of disease from hatchery	MED	Introduction of disease via technicians	MED
Introduction of disease from seeding	MED	Spread of disease from translocation of shell	LOW
Spread of disease	MED	Spread of endemic disease across bivalve populations	LOW
Attraction of other fauna	MED	Impact on wildlife, endangered species and pearl oysters	LOW
Impact of entanglement of protected/ endangered species	LOW	Entanglement in longlines	LOW
Impact of farm lighting on protected/ endangered species	LOW	Panel impact on habitat	LOW
Impact of habitat	LOW	Damage to benthic biota	LOW
Potential for litter	LOW	Litter (e.g. plastic tags, bags) in the water	LOW
Perceived change in water quality	LOW	Reduction in water quality (filtering by oysters)	LOW
Nutrient impacts in sediment	LOW	Nutrient addition	LOW
Reduction of primary productivity	LOW	Alienation of areas from other uses	LOW
Introduction of exotic organisms	MED	Water quality loss (hydrocarbon spill approx. 80 L)	LOW
		Groundwater quality loss (diesel 50 000 L on land)	MED
		Water quality loss (Aviation fuel 35 000 L)	MED
		Water quality loss (chemical treatment of sewage)	MED

2.5.2 Wild capture fishery

Following the 1998 and 2001 assessments of the pearling industry, the WA pearling industry was one of the first to prepare an application to Environment Australia (currently the Commonwealth Department of the Environment, DoTE) outlining the pearling industry's compatibility with the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) requirements for ecologically sustainable development (ESD).

ESD is the concept that seeks to integrate short and long-term economic, social and environmental effects in all decision-making. The WA Government is committed to ESD, and these principles are implicitly contained in the objectives of the FRMA and PA. As part of the assessment process, an environmental risk assessment workshop was held in relation to the wild capture fishery (the POF) and grow-out aspects of the pearling industry in September 2001. The workshop participants included representatives from the pearling industry,

fisheries managers, recreational fishers, conservation groups, Environmental Protection Authority, Environment Australia (currently DoTE) and Conservation and Land Management (currently DPaW). The risk assessment framework applied during the workshop was consistent with the Australian Standard AS/NZS 4360:1999, using a combination of the level of consequence and the likelihood to produce an estimated level of risk associated with the issues in question. Issues of sufficient risk (i.e. Moderate, High or Extreme) were considered to require specific management actions, with a full performance report completed for each issue (Fletcher et al. 2006). Eight issues were identified across the POF and grow-out aspects. No high or moderate risks were identified; one (impact on spawning stock of *P. maxima*) was a low risk and seven were a negligible risk (Fletcher et al. 2006).

The ESD report for the POF (Fletcher et al. 2006) provides a comprehensive overview of fishery information, a major component of which is the explicit determination of the operational objectives, performance measures and indicators used to assess the performance of the fishery. The annual *Status Reports of the Fisheries and Aquatic Resources of Western Australia: state of the fisheries* (e.g. Fletcher & Santoro 2014) reports on the evaluation of performance of the fishery against the sets of ‘agreed’ objectives and performance measures identified during these risk assessments.

In 2008, the risk ratings of all previously identified risks were re-assessed as part of an internal review undertaken by Departmental staff and the Executive Officer of PPA. This review took into account changes in fishing practices and any other relevant external influences in the POF since 2002. As a result of the re-assessment of the risks identified in the original 2002 assessment, the Principle 1 risk rating for the impacts on spawning stocks of oysters was decreased slightly but remained LOW. The ratings of most Principle 2 risks remained unchanged at NEGLIGIBLE; however, one risk was removed from the Principle 2 list altogether (“Addition of materials to the environment — Discarding of shells”) and another was slightly downgraded (“Damage to habitats — Diver activities”, changed from C0 L2 to C0 L1 NEGLIGIBLE). No additional risks were identified (DoF 2008).

The risk ratings of the 2008 assessment were re-assessed again in 2013 by Departmental staff and the Executive Officer of PPA. Key relevant changes since 2008 included the rationalisation of the fleet following the GFC (see Section 4.3); the start of a two-year trial in the reduction of the wildstock minimum legal size from 120 to 100 mm; and the harvest of up to 150 000 pearl oysters > 175 mm SL in size per year, in addition to the culture (120-175 mm SL) wildstock quota during 2012, 2013 and 2014. These changes were supported by the Department’s Research Division, who advised that there were no perceived sustainability issues due to the high abundance of commercially-targeted pearl oysters as a result of high recruitment in 2005 (DoF 2013). As a result of the 2013 re-assessment, the Principle 1 risk ratings for the impacts on spawning stocks of oysters remained unchanged (as NEGLIGIBLE). The ratings of the Principle 2 risk also remained unchanged (as NEGLIGIBLE); however, one additional risk was identified (“Recreational take of specimen shells: C1 L4, LOW”).

All POF risk assessment outcomes are available in the applications provided for assessment against the *Guidelines for the Ecologically Sustainable Management of Fisheries* by the Department on the DoE website at:

<http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013.pdf>.

Table 2.3. Risk ratings of impacts from commercial fishing of *P. maxima*. Sources: Fletcher et al. 2006; DoF 2008; DoF 2013.

Impacts from Commercial Fishing	2002 Rating	2008 Rating	2013 Rating
Impact on spawning stock of <i>P. maxima</i> oysters	LOW	LOW	LOW
Impact of movement on genetic disruption to <i>P. maxima</i> oyster populations	NEG	N/A	N/A
Impact of removing pearl oysters — Loss of habitat for fouling or commensal species	NEG	NEG	NEG
Impact of recreational take of specimen shells on species populations	N/A	N/A	LOW
Impact of commercial fishing on ETP species populations	N/A	N/A	N/A
Impact of removing pearl oysters — Trophic interactions	NEG	NEG	NEG
Impact on <i>P. maxima</i> stock — Discarding shells [†]	NEG	N/A	N/A
Impact on benthic habitats — Diver activities	NEG	NEG	NEG
Impact on benthic habitats — Anchoring	NEG	NEG	NEG
Impact on benthic habitats — Fish holding sites*	NEG	NEG	NEG

[†]Issue removed during 2008 review

*Issue identified subsequent to 2002 ERA workshop

2.5.3 2015 Ecological Risk Assessment of the pearling industry

In August 2015, an ecological risk assessment (ERA) workshop was held to assess the impacts of the WA pearling industry, including the wild capture, hatchery and pearl culture aspects (Travaille et al in prep). The workshop participants included representatives from the pearling industry, the Western Australian Fishing Industry Council (WAFIC), environmental groups, the WA Department of Fisheries and the Northern Territory Department of Primary Industry and Fisheries. The risk assessment framework applied during the workshop was based on the global standard for risk assessment and risk management (AS/NZS ISO 31000), which has been adopted for use in a fisheries context (see Fletcher et al. 2002). The risk analysis process involves the examination of the sources of risk (issue identification), the potential consequences (impacts) associated with each issue and the likelihood (probability) of a particular level of consequence actually occurring. This combination produces an estimated level of comparative risk, which can then be used to assist in determining the level of management response required (Fletcher et al. 2010).

Four aspects were considered for the risk assessment:

- Ecological sustainability — the impact of the pearling industry on ecological resources;

- Community well-being — the contribution of the pearling industry to local, regional and global social and economic well-being;
- External factors — environmental, social and economic drivers that impact the pearling industry's performance; and
- Governance — management processes and arrangements that impact the pearling industry's performance.

Scoping work to identify the issues facing the pearling industry was carried out by Departmental research and management staff and the pearling industry in August 2015 prior to the stakeholder's workshop.

Issues were identified using the assistance of the component tree approach (Fletcher et al. 2002). The identification of issues was guided by the generic ESD component trees to include issues that were applicable to the pearling industry. Industry-specific issues were determined based on previous risk assessments undertaken and identified gaps in the Marine Stewardship Council (MSC) performance indicators (as identified during a pre-assessment of the industry against the MSC standards in 2014).

Fifteen ecological components were identified as potentially impacted by the pearling industry's operations, with 30 possible associated issues. All issues were considered to be a negligible or low risk (Table 2.4; Travaille et al in prep).

Table 2.4. Summary of fishery objectives, ecological components, assessed issues and identified risk ratings for the WA *P. maxima* Pearling Industry at the 2015 ecological risk assessment workshop

Aspect	Industry Objective	Component	Issue	Risk Rating
Retained Species	To maintain spawning stock biomass of <i>P. maxima</i> at a level where the main factor affecting recruitment is the environment	Silver-lipped pearl oyster, <i>P. maxima</i>	Collection of pearl oysters from the wild (WA)	LOW
			Collection of pearl oyster from the wild (NT)	NEGLIGIBLE
			Translocation: impact on genetic structure of pearl oyster populations	NEGLIGIBLE
			Translocation: transfer of diseases between pearl oyster populations (all Zones)	LOW
			Hatchery propagation: impact on genetic structure of pearl oyster populations	NEGLIGIBLE
			Hatchery propagation: transfer of diseases between wild pearl oyster populations	NEGLIGIBLE
			Hatchery propagation: transfer of diseases between hatchery populations	LOW
Non-retained Species	To ensure fishing impacts do not result in serious or irreversible harm to bycatch (non-retained) species populations	Commensal / Fouling ('Piggyback') Species	Loss of habitat for fouling / commensal species populations from pearl oyster collection	NEGLIGIBLE
ETP Species	To ensure fishing impacts do not result in serious or irreversible harm to ETP species populations	Whales and Dolphins	Boat strike	NEGLIGIBLE
			Entanglement in culture lines	NEGLIGIBLE
		Crocodiles	Boat strike	NEGLIGIBLE
			Entanglement in culture lines	NEGLIGIBLE
		Marine Turtles	Boat strike	NEGLIGIBLE
			Entanglement in culture lines	NEGLIGIBLE
		Sharks and Rays	Entanglement in culture lines	NEGLIGIBLE
		Sea snakes	Entanglement in culture lines	NEGLIGIBLE
		Sea birds	Disturbance from industry activities	NEGLIGIBLE
		Shore birds ('waders')	Disturbance from industry activities	NEGLIGIBLE
		Seahorses and Pipefish	Entanglement in culture lines	NEGLIGIBLE

Habitats	To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function	Benthic Habitats	Diver activities	NEGLIGIBLE
			Anchoring	NEGLIGIBLE
			Holding and Dump Sites	NEGLIGIBLE
			Farm Lease Areas	NEGLIGIBLE
Ecosystem Structure	To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes	Trophic Interactions	Removal/additional of materials	NEGLIGIBLE
		Community Structure	Depletion of phytoplankton at farm sites	NEGLIGIBLE
			Introduction of diseases, pests or invasive species	NEGLIGIBLE
Broader Environment	To ensure the effects of fishing do not result in serious or irreversible harm to the broader environment	Air Quality	Fuel usage / Exhaust fumes	NEGLIGIBLE
			Greenhouse gas emissions	NEGLIGIBLE
		Water Quality	Debris/Litter	NEGLIGIBLE
			Oil discharge	NEGLIGIBLE

2.6 Export approval

The material generated by the ESD reporting process, including updated risk assessments and performance reports, has been used to assess the POF under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC) Part 13 (protected species) and Part 13A (wildlife trade).

Initial assessment of the POF took place in 2002, with accreditation under Parts 13 and 13A of the EPBC in 2003 for a period of five years. The POF has subsequently been re-accredited three times, most recently in August 2015 when an extended approval of ten years was granted due to the low environmental risk of the POF. As such, the management regime of the POF has been accredited under the Part 13 of the EPBC Act. Following the approval in 2015, the List of Exempt Native Species (LENS) has been amended until 30th May 2025.

Full details of the current and previous assessments are available at: <http://www.environment.gov.au/topics/marine/fisheries/wa-pearl>.

3. Species and Stock Description

3.1 Silver-lipped pearl oyster, *P. maxima*

3.1.1 Taxonomy and distribution

The silver lipped (sometimes called Gold lipped) pearl oyster (*Pinctada maxima*; Figure 3.1) belong to the Family Pteriidae, which is a small family of bivalve molluscs. Four species of the genus *Pinctada* occur in WA: *P. maxima*, *P. albina*, *P. fucata*, and *P. margaritifera* (Hynd 1955). Of these only *P. maxima*, *P. margaritifera* and *P. fucata* are currently being used for pearl production in Western Australia. *P. maxima* is the only species managed under the PA and is the world's largest species of pearl oyster.

P. maxima is distributed within the central Indo-Pacific region, bounded by the Bay of Bengal to the West, Solomon Islands to the east, the Philippines to the North, and Northern Australia to the south (Figure 3.2). Originally distributed from the shallow sub-tidal, it occurs in depths in excess of 50 m. Some early reports from the Sulu Islands in the Philippines suggested that *P. maxima* live as deep as 120 m (Talavera 1930). Strong tidal currents appear to be the common habitat / environmental feature of both historical and presently important areas of wild stocks (Figure 3.2).

(a)



(b)



Figure 3.1. *Pinctada maxima* in its (a) natural habitat, and (b) processed for sale.



Figure 3.2. Distribution of silver-lipped pearl oysters (*Pinctada maxima*) and areas of historical and current wild fisheries and pearl farms.

3.1.2 Stock structure

Silver-lipped pearl oysters are a broadcast spawner that can each produce greater than 30 million viable eggs under hatchery spawning conditions, and whose egg and larval stages spend up to 3 weeks in the plankton. It is widely dispersed within tropical WA and the Indo-Pacific; however, the boundaries of commercially fished populations are Exmouth Gulf in the south-west of its range, and Lacepede Channel in the north-east, a distance of about 1200 km. Within these populations, areas fished are discrete and separated by large distances. The first studies of allozyme variation found little variation between Exmouth Gulf and Cape Bossut (80 Mile Beach, shallow), indicating high connectivity over 800km (Johnson and Joll 1993). The pattern was consistent with other species along this coastline with planktotrophic larvae (Johnson and Joll 1993), and is likely to be correlated with the extensive water currents arising from six to twelve metre tidal ranges.

Benzie and Smith (2006) developed microsatellite DNA markers for pearl oysters and examined connectivity in more detail within WA, Northern Territory and Indonesian populations. They compared Lacepedes, 80 Mile Beach (shallow), 80 Mile Beach (deep), Port Hedland, and Exmouth Gulf populations, found extensive gene flow and large effective population sizes, and confirmed the hypothesis of high connectivity amongst populations. However, there was some evidence for genetic differentiation between Exmouth Gulf and the more northern populations (Benzie and Smith 2006). Overall, commercially fished populations of pearl oysters in Western Australia are linked closely at a genetic scale. This is certainly the case for shallow and deep populations in the 80 Mile Beach region that are the mainstay of the POF.

3.1.3 Life history

Pearl oysters are a protandrous hermaphrodite. The animals mature first as males, at approximately three to four years of age and at a size of 110 to 120 mm, beyond this the animals begin to undergo a sex change and become female (Figure 3.3). By 170 mm in length, half of the animals are males and half are females. By 190 mm the majority of the population is female. Since the animals can spawn every year, each individual can function as both a male and then a female for several spawning seasons. Very few animals are both male and female simultaneously (Rose et al. 1990; Rose and Baker 1994), however pearl oysters are rhythmical hermaphrodites, and can have more than one sex reversal during their lifetime (Saucedo and Southgate 2008). This is thought to be related to a complex interaction of endogenous factors and varying environmental conditions. The principal hypothesis is that “maleness” is favoured when energy reserves are low, while “femaleness” is favoured when energy reserves are high.

3.1.3.1 Movements

The movements of pearl oyster larvae prior to settlement on the benthos are dictated to by physical oceanographic processes such as wave action, prevailing winds and currents. Condie et al. (2006) determined that *P. maxima* larvae on WA’s north-west shelf are predominantly transported < 30 km, however some as far as 60 km. During the juvenile and adult phases of the life cycle of *P. maxima*, it attaches to the sea bottom by tiny threads. *P. maxima* require a hard surface for attachment, once attached the connection is permanent.

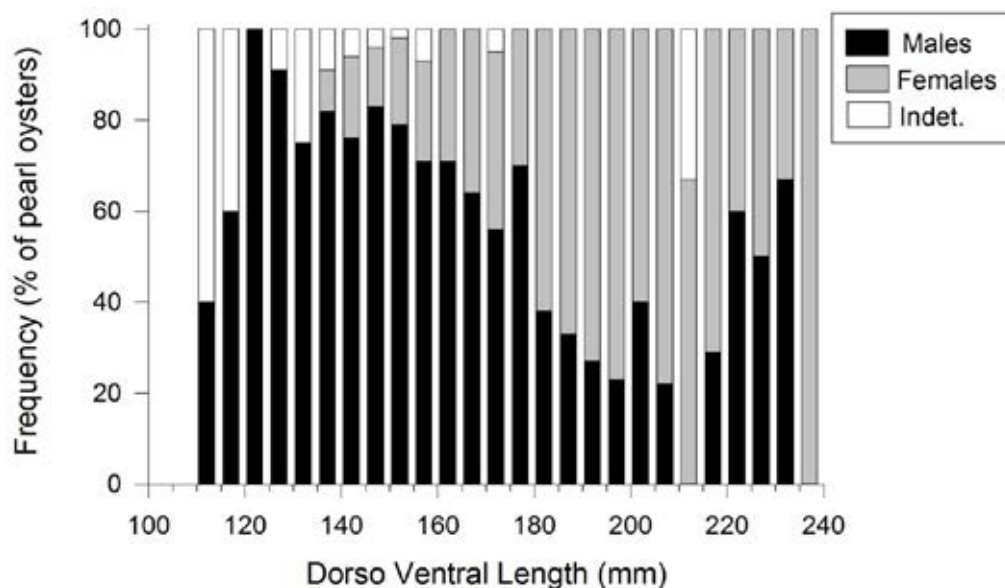


Figure 3.3. Per cent frequency distribution of sex by size for *Pinctada maxima*. Data sourced from Hart and Joll (2006).

3.1.3.2 Reproduction

3.1.3.2.1 Spawning season

The breeding season of *P. maxima* starts in the spring months of September or October extending to the autumn months of April and May. Although there is variability from month to month, the primary spawning occurs from the middle of October to December. A smaller

secondary spawning occurs in February and March (Rose et al. 1990; Rose and Baker 1994). Collection of settling spat in the field has confirmed the spawning periodicity (Knuckey, 1995).

P. maxima are broadcast spawners; they release gametes (both sperm and eggs) into the water column during the spawning season (October to December), where fertilisation occurs. The ova develop into a tiny veliger stage and settlement usually occurs around 28 to 35 days post-hatching. When they are ready to metamorphose they settle to the bottom and test for a suitable habitat. If an appropriate area is found, they settle on it and metamorphose into the juvenile stage. If no suitable settlement site is located within a short period the animals will metamorphose and die.

3.1.3.2.2 Size at maturity

Size at-maturity for male *P. maxima* is around 110 mm SL, females were identified from 135 mm SL onwards and the sex ratio reached 50:50 female to male at approximately 170 to 180 mm SL (Figure 3.3). By 190 mm SL the majority of the population is female.

3.1.3.3 Size-fecundity relationships

Egg production by an individual female is extremely high. Laboratory studies have shown that females can release from two to 12 million ova in a single spawning event (Rose and Baker 1994), however the estimated number of eggs found in mature female gonads (> 170 mm SL) varies between 20 and 50 million (Figure 3.4). No significant correlation was found between fecundity (no of eggs) and SL of *P. maxima* for either fixed or dried gonad samples (Figure 3.4).

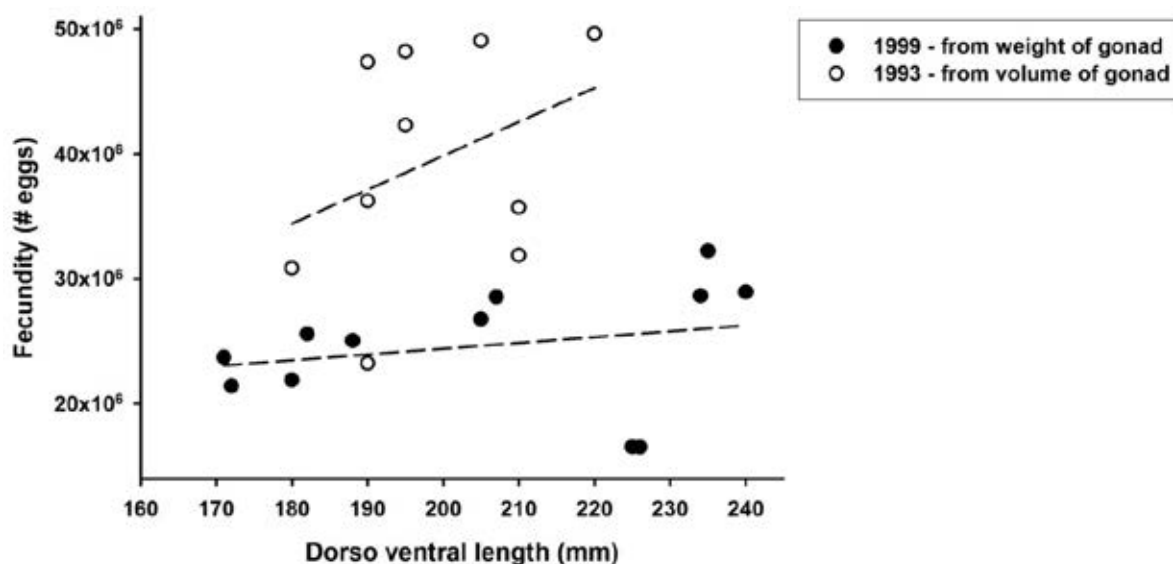


Figure 3.4. Fecundity estimates as a function of shell length in mm for two different methods. Figure modified from Hart and Friedman (2004).

3.1.3.4 Factors affecting recruitment of juveniles

Recruitment of juveniles in the *P. maxima* fishery is measured by annual surveys of the Age 0+ and 1+ year classes (Hart and Joll 2006). Sea surface temperature (SST), rainfall, and wind conditions were all found to influence settlement, with SST being the most important factor (Hart et al. 2011). Annual variation in settlement can result in major changes in

abundance and this variation appears primarily driven by environmental conditions. For more details see Hart et al. (2011).

3.1.3.5 Morphological relationships

Being irregular shaped bivalves has resulted in various morphometric measures being applied to *Pinctada* spp. These include dorso-ventral measurement (DVM), anterior-posterior measurement (APM), thickness, and hinge depth (Figure 3.5). The common measurement used is the DVM, which is the metric collected for all growth, mortality, length-frequency sampling and population surveys. The current minimum legal length (100 mm) of the POF is a DVM measurement.

For the remainder of this document, all measurements referring to shell length (SL) are DVM measurements unless otherwise noted.

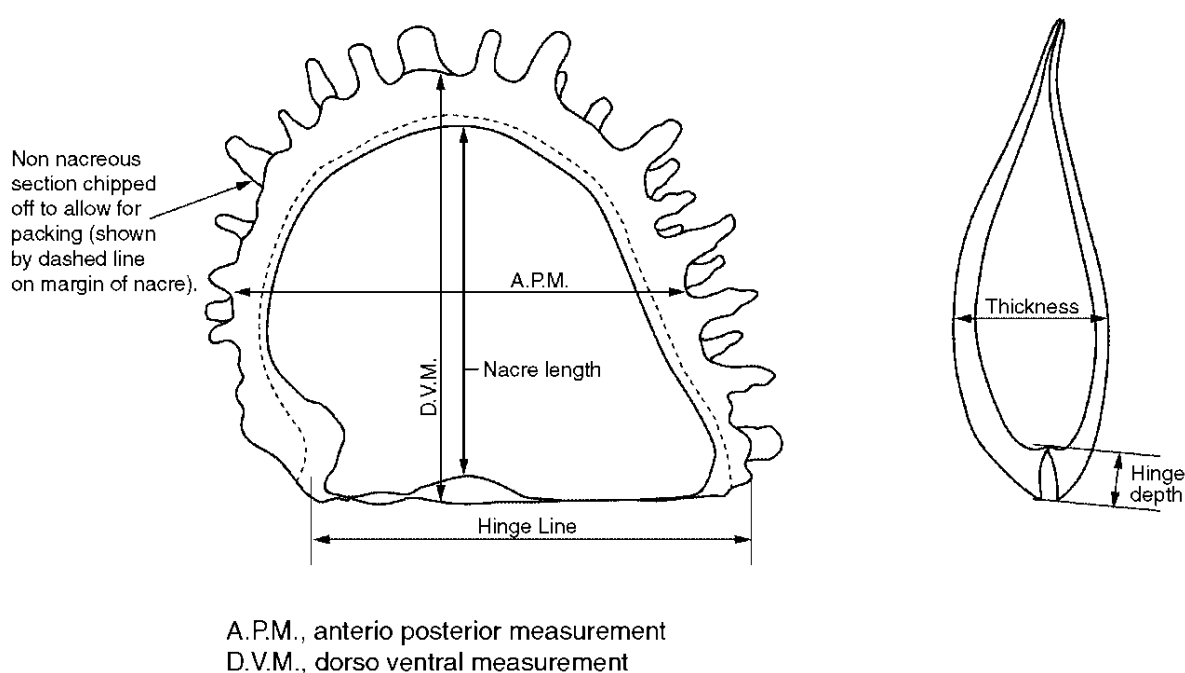


Figure 3.5. Morphometric measurements commonly used to measure the morphology of *Pinctada maxima*.

3.1.3.5.1 Length-width relationships

A description of the length-width relationships in *P. maxima* is found in Figure 3.6. There is a high correlation ($r^2 > 0.95$) between the three major morphometric measurements in this species (DVM, APM, and shell thickness).

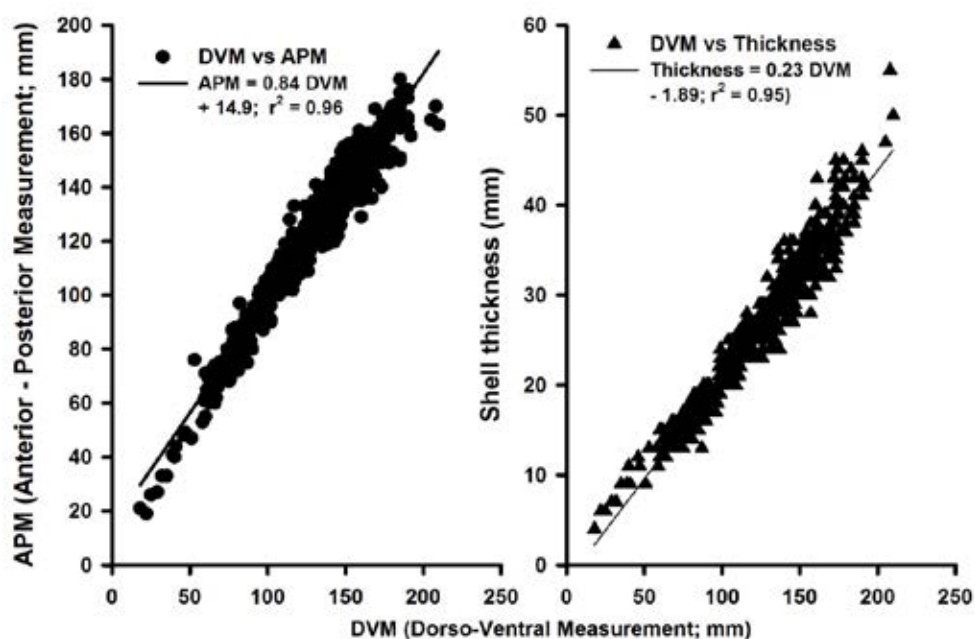


Figure 3.6. Dorso-ventral measurements (DVM) in comparison to (a) anterior-posterior measurement (APM) and (b) shell thickness.

3.1.3.5.2 Weight-length relationships

The WA POF is centred on the collection of wild pearl oysters for inoculation with nuclei to produce pearls. Additional small scale markets for MOP and pearl oyster meat are accessed by the POF, however, are of comparatively minor importance. It is for these reasons that the size of the pearl oyster is the focus of the POF, not the weight of the pearl oyster.

3.1.3.6 Age and growth

P. maxima growth is typically described by a von Bertalanffy growth curve. Growth parameters (L_{∞} , K) were estimated at 210 mm DVM (± 16 mm SD) and 0.74 at the Lacepede Islands, L_{∞} of 199 mm DVM (± 6 mm SD) and K of 0.79 on 80 Mile Beach, and L_{∞} of 194 mm (± 6 mm SD), and K of 0.72 at Exmouth Gulf respectively (Figure 3.7). In the main section of the POF pearl oysters generally spend about three years in the exploited phase of the life cycle (100-175mm SL) until they reach a larger size (>175 mm SL) (Figure 3.7). Once this size is reached the pearl oysters are considered no longer suitable for round pearl culture. Large oysters of >200 mm have been estimated to be 15 to 20 years old and the maximum DVM recorded for an individual for *P. maxima* is 270 mm (Rose and Baker 1994).

3.1.3.7 Diet

Pearl oysters like other bivalves are suspension feeders. They collect nutrients from the water by trapping suspended particulate organic matter in mucus that coats the gills; these particles are then conveyed by cilia to the mouth (Campbell 1996). Clearance rates, respiration and excretion have been shown to increase exponentially with body size for *P. maxima* (Yukihira et al. 1998). The variety of substrates *P. maxima* inhabits, such as: mud, sand, gravel, seagrass beds and deepwater reefs, can influence the composition and quantity of nutrients available, hence influencing growth and maturation.

3.1.3.8 Natural mortality

Hart and Friedman (2004) determined natural mortality for adult *P. maxima* by two methods. The first method involved tag and recapture studies conducted on fixed lines. The second method involved length converted catch-curve (Pauly 1984) fitted to data for the unfished portion of the stock. Natural mortality (M) from the catch-curve analysis ranged from 0.18 or 16.5 % per year (80 Mile Beach, inshore shallow) to 0.1 (10 %) at the Compass Rose deepwater stocks (Figure 3.8). This trend was correlated with depth, i.e. highest mortality in shallower waters (10 – 15 m) and lowest in deep (30 – 40 m) in the 80 Mile Beach stocks. Tag and recapture studies estimated M to be 0.02 (Hart and Joll 2006).

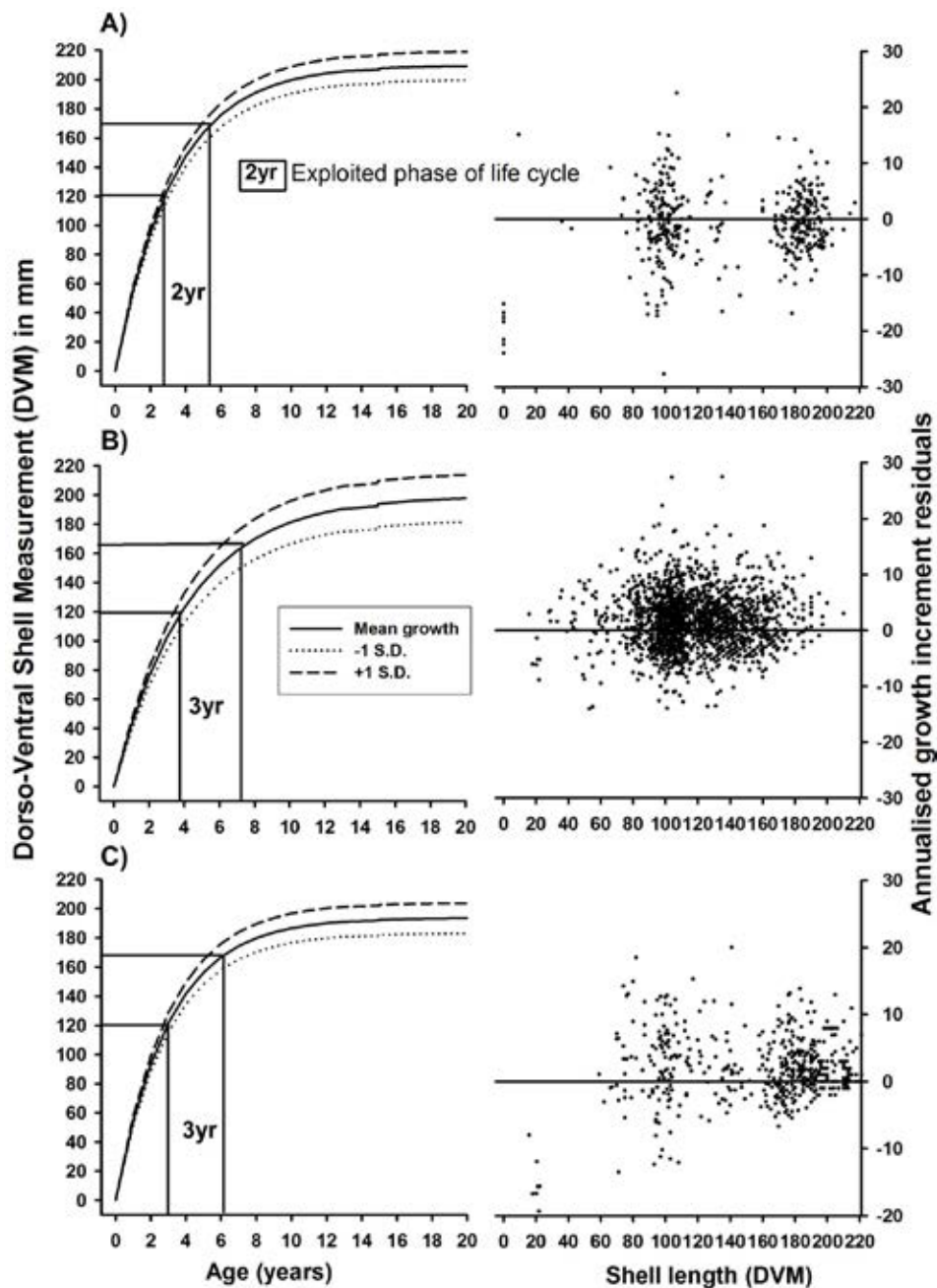


Figure 3.7. von Bertalanffy growth curves for each population of *Pinctada maxima* (A – Lacepede Islands; B – 80 Mile Beach; C – Exmouth Gulf) and annualised growth increment residuals. The exploited phase of the life cycle in each population is also shown.

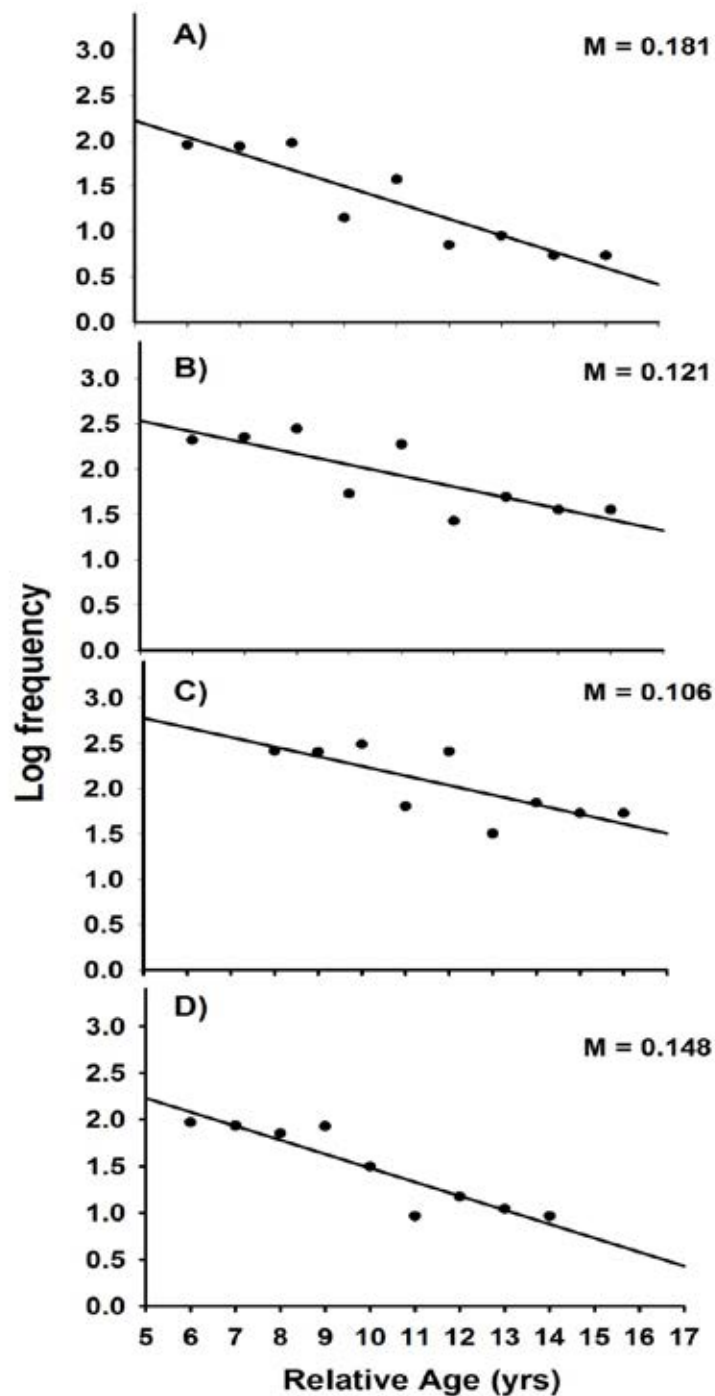


Figure 3.8. Natural mortality (M) curve for *Pinctada maxima* sampled at 4 populations. A) 80 Mile – Inshore shallow, B) 80 Mile – Offshore shallow, C) Compass Rose, D) Lacepede Islands.

3.1.3.9 Parasites and disease

An infection of pearl oysters, attributed to a *Haplosporidium* sp. parasite, has been detected on three occasions in WA. The areas of infection include the digestive gland epithelium, gills and mantle (Bearham et al. 2008). Although the incidence and extent of the infestations have been minimal, this parasite is considered to represent a serious concern to the pearling industry in WA (Bearham et al. 2008).

Pearl oysters harvested from wild stocks and transferred to farms in both WA and NT can experience considerable levels of infestation of bioeroding sponges (*Cliona* sp.). *Cliona* sponges burrow into the shell causing damage and occasionally death, rendering the halfshell, and occasionally the pearl, unsaleable. Estimates of cost to the industry from *Cliona* sp. run into the millions of dollars per year. A total of seven bioeroding sponge species were found in pearl oyster shell samples from the fishing grounds in North Western Australia: *Pione velans*, *Cliona dissimilis*, *Cliona orientalis*, two unidentified species of *Cliona*, and two unidentified species, one of *Aka* and one of *Zyzya*. *Pione velans* is the dominant species followed by *C. dissimilis*. The life history traits of *Cliona* sp. (sexual and asexual reproduction) may be allowing them to exploit previously unavailable niches created by industry harvesting and cleaning practices, and potentially increasing their population sizes beyond what would naturally occur (Daume et al. 2009).

In 2006, Oyster oedema disease (OOD) caused mass mortalities in farmed *P. maxima* in Exmouth Gulf, WA. Killing at least 2.8 million pearl oysters, 60 % of the recently seeded pearl oysters died along with mortality rates of 90% or higher for smaller pearl oysters, with all size classes affected. The highest mortalities were reported in smaller spat, 40 – 50 mm. Attempts to transmit the disease under experimental conditions to healthy pearl oysters in a different occasion proved unsuccessful, with the diseased pearl oysters recovering (Humphrey 2008; Humphrey and Barton 2009). Humphrey and Barton (2009) undertook experiments in which they exposed pearl oyster spat derived from a region in the NT with no history of OOD to tissue homogenates from oysters diagnosed with OOD in WA. As there were no deaths or disease resulting from the exposure of the pearl oyster spat to the homogenate, the study findings did not support the hypothesis that OOD is infectious. Based on these results, imports of live pearl oysters from WA were continued (Humphrey and Barton 2009). Studies into aspects of OOD in pearl oysters to assist in mitigating the impacts and understand pathways to disease and disease response in this species are ongoing (DoF 2011), but to date there has been no detection of OOD in wild stocks of *P. maxima*.

3.1.3.10 Effects of climate change

There are no documented effects of climate change on *P. maxima*. Given that recruitment is variable and influenced by a range of environmental factors including SST (see Section 3.1.3.4) predicted increases in the global temperature might plausibly affect this species (Hart et al. 2011). A risk assessment of the potential effects of climate change on fisheries in WA ranked pearl oysters as being sensitive to climate change but its current exposure was medium resulting in an overall risk ranking of medium-high (Caputi et al. 2015).

4. External Influences

External influences include other activities and factors that occur within the POF that may or may not impact on the productivity and sustainability of fisheries resources and their ecosystems. The main external influences included here are catch from other fisheries, environmental factors, market influences, tourism, liquid natural gas (LNG) exploration and introduced species.

4.1 Catch from other fisheries

The POF is the only commercial fishery in WA that harvests *P. maxima*, and there are currently no recreational or indigenous fisheries for this species (Fletcher et al. 2006).

4.1.1 Customary use

Pearl oyster shell is an important resource of cultural significance to the Indigenous people of Australia and has been harvested for at least 20,000 years (Yu and Brisbout 2011). Aboriginal Australians of the west Kimberley harvested pearl oysters from shallow waters and had well established traditional trading networks that extended throughout Australia (Akerman and Stanton 1994, Figure 4.1). The pearl oyster meat was consumed and the shell used for decoration and other cultural purposes. The shells were cleaned, shaped and often decorated with designs that were worn for ceremonial occasions. The *P. maxima* pearling industry was initiated in 1861 through trade between early explorers and Aboriginal Australians (Southgate and Lucas, 2008).

There is currently no managed customary fishery and catch of *P. maxima* is considered negligible.

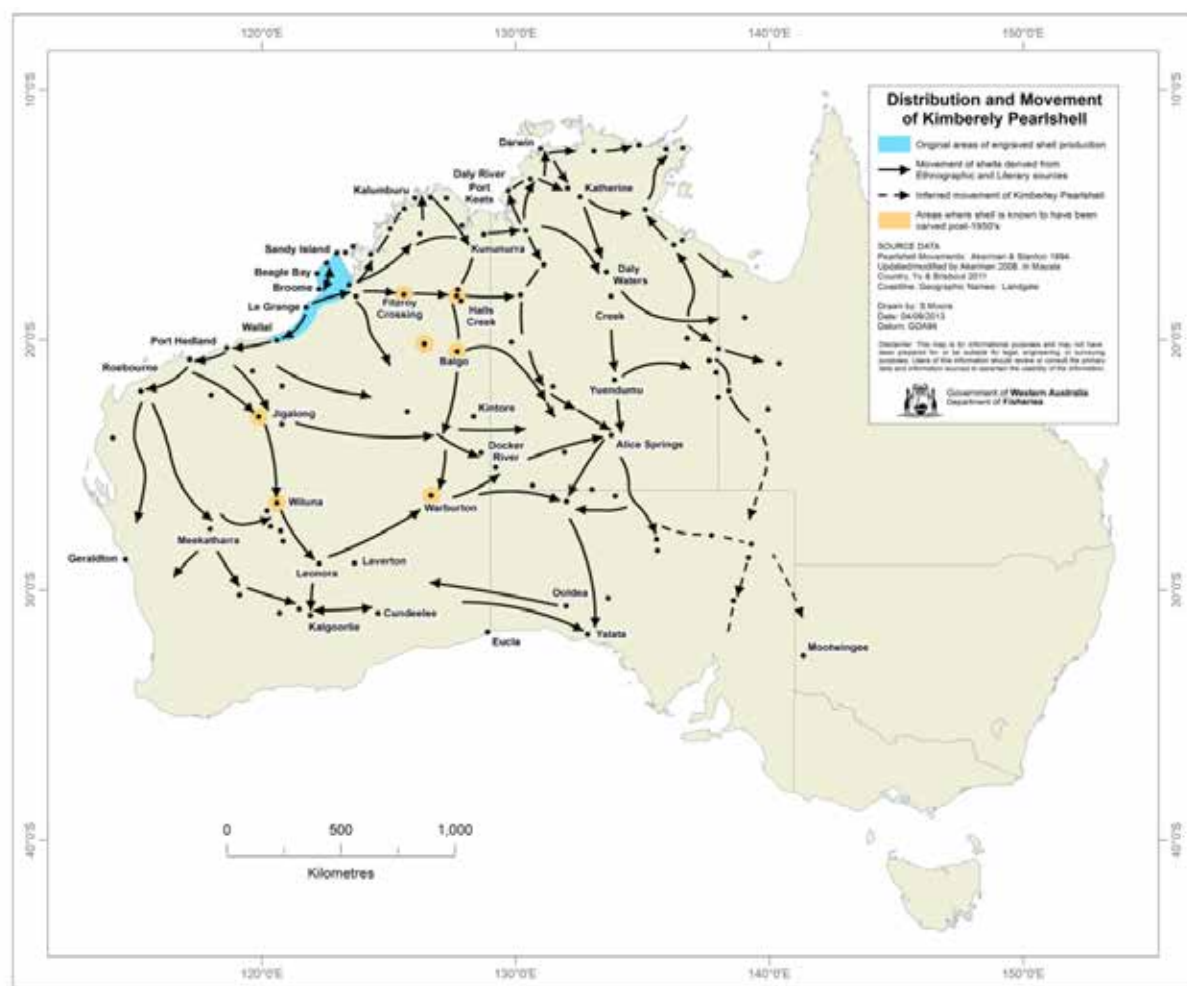


Figure 4.1. Custom distribution and movement of Kimberley Pearl Shell (Source: Akerman and Stanton 1994).

4.2 Environmental factors

4.2.1 Cyclones

Severe tropical cyclones seasonally occur throughout the area that pearl oysters are taken, and historically have severely impacted on both pearl farms and the habitat of the pearl oyster beds of the POF.

4.2.2 Disease

In October 2006, the Department received reports of significant, unexplained mortalities in farm-based silver-lipped pearl oysters from farms located in Exmouth Gulf and the Kimberley. Seeded and unseeded oysters were affected, with hatchery spat appearing to particularly vulnerable. The mortalities seemed to be linked to an infectious agent, which for administrative purposes has been termed ‘Oyster Oedema Disease’ (OOD) (see Section 3.1.3.9).

Immediately following the reports, the Department enacted the *Pearling Industry Emergency Incident Management Plan*, which included the formation of a Department/industry taskforce to monitor and manage the incident. The taskforce met periodically and jointly developed a specific

translocation protocol (see Appendix A). The taskforce also commissioned two independent epidemiological studies into the mortality event by AusVet Animal Health Services.

In early 2008, the Department and the WA Department of Agriculture and Food cooperatively made two amendments to the *Enzootic Diseases Regulations 1997* (EDR) to better manage any mortality events. Firstly, OOD was listed as a mollusc disease in the EDR, thus requiring lease holders to report if they have oysters that have (or may have) the disease. The second amendment improved the mechanisms for disease testing of pearl oysters and approval processes for the transport of pearl oysters when they may be (or have been) affected by the disease (DoF 2008).

4.3 Market influences

While other countries also produce pearls from *P. maxima* pearl oysters, there is international recognition that Australian produces the finest pearls in the world, due to their size and quality. There are five main virtues that determine the quality of a pearl:

Lustre — Describes the interplay of refraction and reflection of light from the surface and depths of the pearl. Lustre gives the pearl is glow and aura. The higher the lustre, the more valuable the pearl.

Complexion — Pearls may be more or less blemished with spots and various marks on the surface. Although blemishes may not detract from a pearls appeal, they decrease the value.

Size — Larger pearls are more valuable due to their size and rarity. High quality pearls above 15 mm in size are particularly rare.

Shape — Although round pearls are traditionally the favourites, many of the other shapes such as baroque and circle are gaining in popularity.

Colour — Australian pearls come in a range of colours, yellow, white, silver, pink, green, apricot, cognac and champagne. The favoured pearl colour is up to the beholder, but white with pink or rainbow overtones are the most popular.

4.3.1 Global demand

The GFC had a major impact on the pearling industry due to reductions in demand for pearls around the world. This resulted in a reduction in pearl production, rationalisation and consolidation of pearling leases and reduction in the utilisation of the wildstock quota and a reduction in the gross value of the fishery.

4.4 Tourism

Each year around 30,000 people visit Broome and the Kimberley region. A large attraction for tourists is the pearling industry with interest in both the history of pearling and current day operations. Presently there are two pearl farms that offer tours which allow tourists to learn about the history of the pearling industry and pearl culture process, see farm operations, and gain an appreciation of early grading. Other tours related to the pearling industry offered in Broome are tours of luggers and old China town.

In addition to the pearling industry there are many other activities for tourists in the Kimberley and Broome region with the most common including charter boat fishing tours, whale watching, scenic flights, indigenous and cultural tours and Kimberley cruises on liveaboard vessels.

To accommodate the large number of tourists there are numerous caravan parks, hotels and restaurants. Tourism is typically seasonal, during the dry cooler months between May and September each year.

4.5 State commercial fisheries

The Department manages commercial and recreational fishing in the State coastal waters (generally 3 nm). By way of the *Offshore Constitutional Settlement 1995* (OCS) agreement between the State and Commonwealth Governments, control is also given to WA for most fisheries which operate out to 200 nm from the coast (except for trawling where WA's jurisdiction is limited to the 200 m isobath). There are 47 different state-managed commercial fisheries that operate within the WA state managed waters- more information on WA fisheries is within the annual State of Fisheries report (Fletcher and Santoro 2014).

The main fisheries in the NCB focus on tropical finfish, particularly the high-value emperors, snappers and cods. These species are taken by the Pilbara Demersal Scalefish Fisheries (trawl, trap and line sectors) and the Northern Demersal Scalefish Fishery. The typical catch is in the order of 3000 t annually at an estimated annual value of around \$ 12 million, making these fisheries the most valuable finfish sector in the state. A number of other finfish fisheries operate in the NCB, including near-shore beach seining and gillnetting for barramundi and threadfin salmon (the Kimberley Gillnet and Barramundi Managed Fishery), surface trolling for Spanish mackerel (the Mackerel Managed Fishery) and demersal longline and pelagic gillnet fishing for sharks (the Northern Shark Fishery).

The NCB also has a number of small, limited-entry trawl fisheries for prawns, producing around 700 t annually and valued at around \$10 million. These fisheries include the Onslow, Nickol Bay, Broome and Kimberley Prawn Managed Fisheries (collectively referred to as the North Coast Prawn Managed Fisheries).

Two small trap-based crab fisheries also exist in the bioregion, targeting blue swimmer crabs in the Pilbara (the Pilbara Developing Crab Fishery) and mud crabs in the Kimberley (the Kimberley Developing Mud Crab Fishery).

Sea cucumbers (also known as *bêche-de-mer* or *trepang*) is collected by hand by divers and waders throughout the Kimberley region as part of the *Bêche-de-Mer* Fishery. Catches are mainly comprised of two species, sandfish (*Holothuria scabra*) and redfish (*Actinopyga echinites*).

The Trochus Fishery is a small fishery based on the collection of a single target species, *Tectus niloticus* from King Sound and the Buccaneer Archipelago. This fishery is operated by the Bardi Jawi and Mayala Aboriginal Communities, who have been collecting trochus in this area since the 1960s.

4.6 Commonwealth fisheries

Commonwealth fisheries are managed by the Australian Fisheries Management Authority (AFMA). There are six Commonwealth fisheries off the WA Coast: the Western Skipjack Fishery, the North West Slope Trawl Fishery, the Northern Prawn Fishery, Southern Bluefin Tuna Fishery, the Southern and Western Tuna and Billfish Fishery and the Western Deepwater Trawl Fishery. Most of these Commonwealth fisheries operate in deeper waters and the potential for interaction with the POF is low.

For more information on these fisheries see the AFMA website:

<http://www.afma.gov.au/managing-our-fisheries/fisheries-a-to-z-index/>

4.7 Oil and gas industry

The majority of the offshore oil and gas industry in WA is focused in the northern part of the state (Figure 4.2). The main disturbances associated with oil and gas exploration and production include noise pollution from seismic surveys, potential for fish movement/impact arising from seismic surveys, disturbance to the marine habitat through drilling and/or dredging activities, release of produced formation water, shipping and transport activities and oil spill accidents.

The petroleum industry is regulated through the *Petroleum (Submerged Lands) Acts 1967*, the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999* (PSLR) and the EPBC. A key feature of the PSLR is the requirement that an operator submit an Environment Plan before commencing any petroleum activity (CoA 2006).

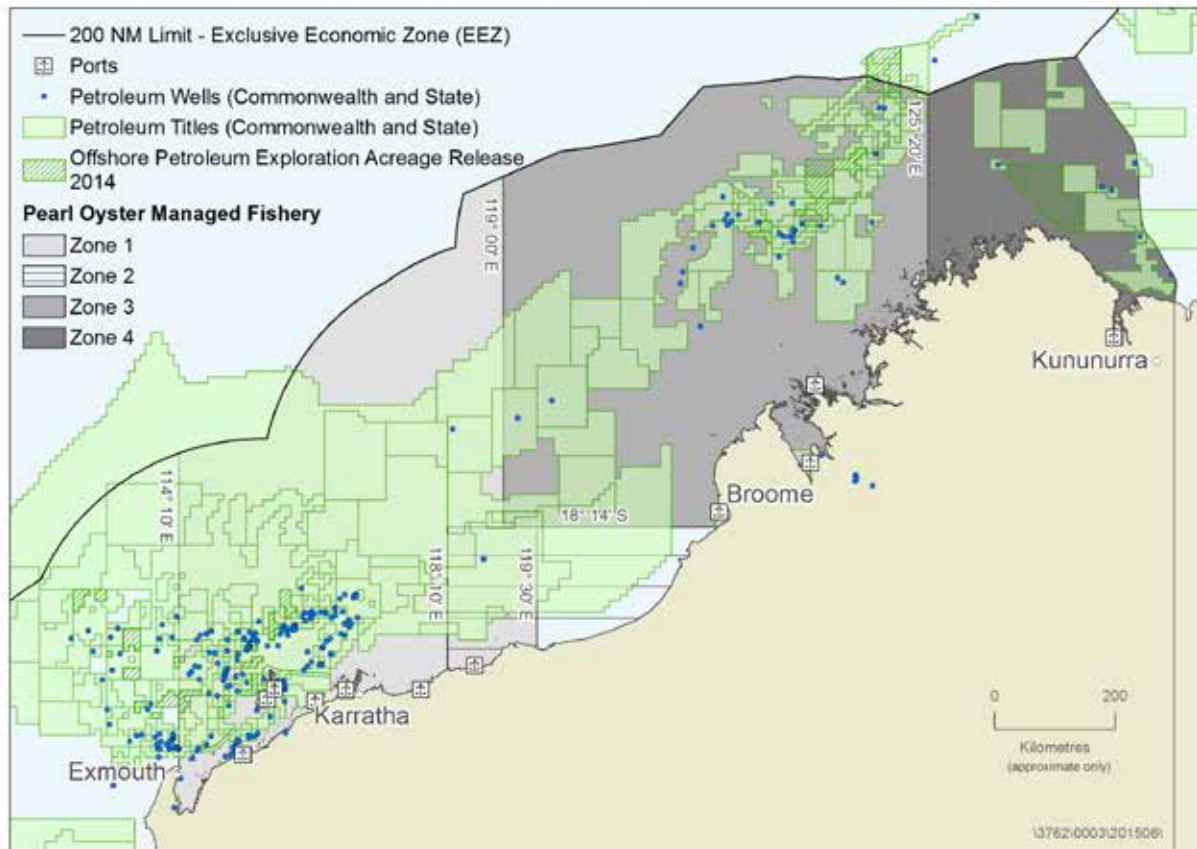


Figure 4.2 Oil and gas industry wells and exploration areas in the WA Pearl Oyster Fishery area

4.8 Shipping and ports

Shipping plays an important role in WA's economy, with major ports distributed along the WA Coast (Figure 4.3). The exports and imports at each port vary in accordance to proximity to different resources with major exports including: oil and petroleum, iron ore, agricultural products and salt.

There are several major ports in WA located in Broome, Dampier, Port Headland, Geraldton, Albany, Bunbury and Esperance (DoT 2014).

The only formal shipping routes off the WA Coast are in the north west of the state. Shipping activity is typically low throughout the state, except for the NCB with this shipping associated with mining activity (Figure 4.3).

An increase in shipping and port expansion associated with growth of the resources sector has potential implications for the marine environment. Potential threats include loss or contamination of marine habitats as a result of dredging and sea dumping, oil spills, interactions between vessels and protected species and the introduction of marine pests (DEWHA 2008). The environmental management of shipping is governed by a range of national and international agreements, regulations and codes of practice.

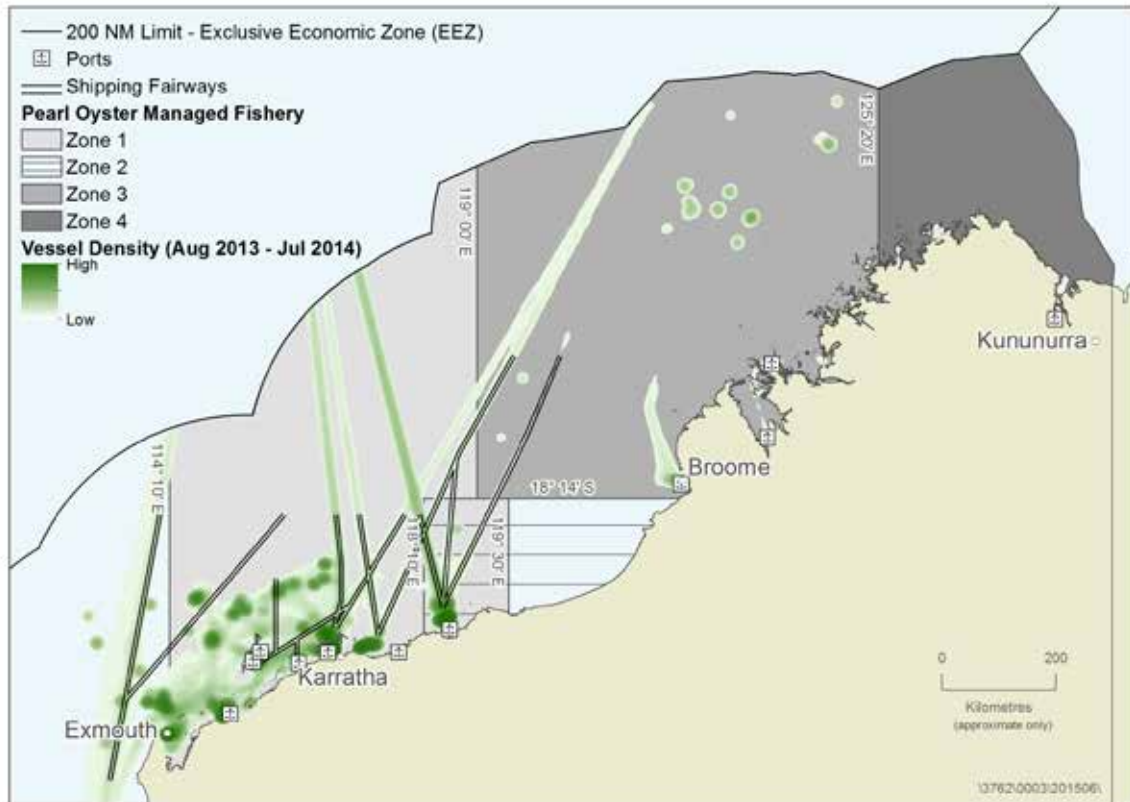


Figure 4.3 Major ports and shipping activity in the WA Pearl Oyster Fishery area

4.9 Introduced pests and diseases

The introduction and spread of marine pests in WA waters poses a threat to native biodiversity and can have widespread effects on both the economy and public health. To detect potential incursions the Department have developed a marine pest monitoring program for the major ports along the WA coast, the results of which are reported annually (Fletcher and Santoro 2014).

MSC Principle 1

5. Stock Status

5.1 Current stock status

Multiple lines of evidence indicate that the stock is above the point of recruitment impairment with a high degree of certainty. These include:

- Effort has been tightly controlled for over 20 years (Figure 2.10) and has remained relatively stable, with the exception of 2009 and 2010 when it fell substantially due to economic conditions. Factors affecting fishing efficiency have been incorporated in the assessment.
- Catch has successfully been controlled by the TAC for 30 years (Figure 2.8 and Figure 2.9) and the catch has been demonstrated to be very accurately recorded.
- Catch rates in recent years have been exceptionally high due to good recruitment and although they are now returning to normal levels, they are still above the target reference point (Figure 7.1).
- Although variable, there has been consistent recruitment of pearl oysters in the 19 years of 0+ spat monitoring. This has included an exceptional year of recruitment in 2005, which was the highest ever recorded (Figure 7.9). The variation in recruitment has been well explained by environmental factors.
- The POF has operated for over 100 years and there has never been an obvious stock collapse; current catch levels are much lower than in the 50 year period from 1890 to 1940 (Figure 2.1).
- A relationship between catch rates and previous recruitment has been demonstrated to be highly informative for predicting future abundance, allowing for pre-emptive management. The predictions for 2013 and 2014 were that abundance will be lower than 2012, but above the target catch rate (Figure 6.13). The catch rates for 2013 and 2014 occurred as predicted and predictions for 2015 and 2016 indicate a small improvement (Figure 6.14).
- Between 1987 and 2009, the female breeding stock (>175 mm SL) was not fished (on a voluntary basis by industry), thus providing a very high level of protection to the overall stock. Since this time, very limited and tightly controlled fishing of the breeding stock has taken place.

Stock status is within the target catch rate reference points and has been for over a decade. The current system of adjusting the sustainable harvest level (SHL) and TAC in response to predicted abundance will continue to be applied and it is expected that stock status will remain within the target range for the foreseeable future.

5.1.1 Stock status in relation to target reference points

The POF uses standardized legal-size catch rates (SCPUE) to determine whether the pearl oyster stock is at appropriate levels and uses a model that incorporates catch rates and recruitment levels to provide recommendations annually on the SHL. Standardized catch rates have been above the lower end of the proposed target reference point (i.e. 25 oysters per hour) since the SCPUE index began in 2003 (Figure 7.1), indicating that the stock has been above its target reference point for ~ 10 years. Because the management system in place responds to the state of the stock, with the TAC adjusted as required, the stock has fluctuated above a level where fishing mortality is having an effect on recruitment. That is, variations in stock size are attributed to natural variations in recruitment.

5.2 Genetic outcome

Risk assessments undertaken in 2002 (see Section 2.5.2) and 2015 (Trevaille et al. In Prep) concluded that pearl culturing activities were a low to negligible risk to the genetic population structure of *P. maxima*. Studies undertaken by Johnson and Joll (1983) and by Benzie and Smith (2006) found WA and NT populations of *P. maxima* to be markedly different genetically. Therefore, despite substantial historical translocation of *P. maxima* from WA into NT (see Johnson & Joll, 1993) the regional population structure has been maintained, and is not genetically homogenous, suggesting that translocation and pearl culturing has had minimal impacts.

The only other published study pertinent to the impact of cultured stock on the genetic structure of wild pearl oyster populations concerns *P. margaritifera*. That study showed no impact of extensive pearl farming on the genetic structure of wild populations (Arnaud-Haond et al. 2003).

6. Stock Assessment

6.1 Stock assessment methods

In summary, *P. maxima* stocks in WA are assessed each year using annual indices of catch rate and comparing these to the specified reference points. The indices of catch rate are standardised using generalised linear regression models (GLMs) to account for effects of a range of factors. In addition, a relationship between SCPUE and previous recruitment is used to predict future commercial catch rates (abundance). This provides an early warning system allowing pre-emptive management to prevent stock depletion or take commercial advantage of predicted high abundance. Additional support to this assessment is provided by catch length frequency and population length frequency surveys to verify the spatial pattern of the exploited populations.

6.1.1 Assessment of the culture component of the POF

6.1.1.1 Spatial catch and effort

Fishing effort in 2014 was spread across a larger area than normal (Figure 6.1). This was due largely to the low catch rates experienced in the main grids of the POF. The desire of the pearling industry to maximise CPUE led to searching for new grounds and exploitation of previously lightly fished areas. Thus, the “Shoonta Patch” (Grids 4748 to 4751; Figure 6.1), which had not been fished since 1995, received a substantial fishing effort in 2014 (93,000 pearl oysters). Similarly, Compass Rose, the deeper water stock (Grid 4252 to 4254; Figure 6.1) was also fished heavily with a record of 96,000 pearl oysters harvested.

Catch rates in the two main producing areas of the POF, which have supplied 50% of the total catch in the last 30 years, were at their lowest levels seen in a decade (Figure 6.2; Grids 4355 and 4454). This was predicted by the 2012 forecast model, which models growth of the Age 0+ settlement density from 4 and 5 years previously (Figure 6.13). Examination of settlement data for the years relevant to 2014 (2009, 2010), shows those years, particularly 2010, as experiencing the lowest recorded settlement since 1993 (Figure 6.11).

In 2014, an update of the 2012 forecast model showed that standardised CPUE in 2013 and 2014 was within the range predicted by 2012 model (Figure 6.14).

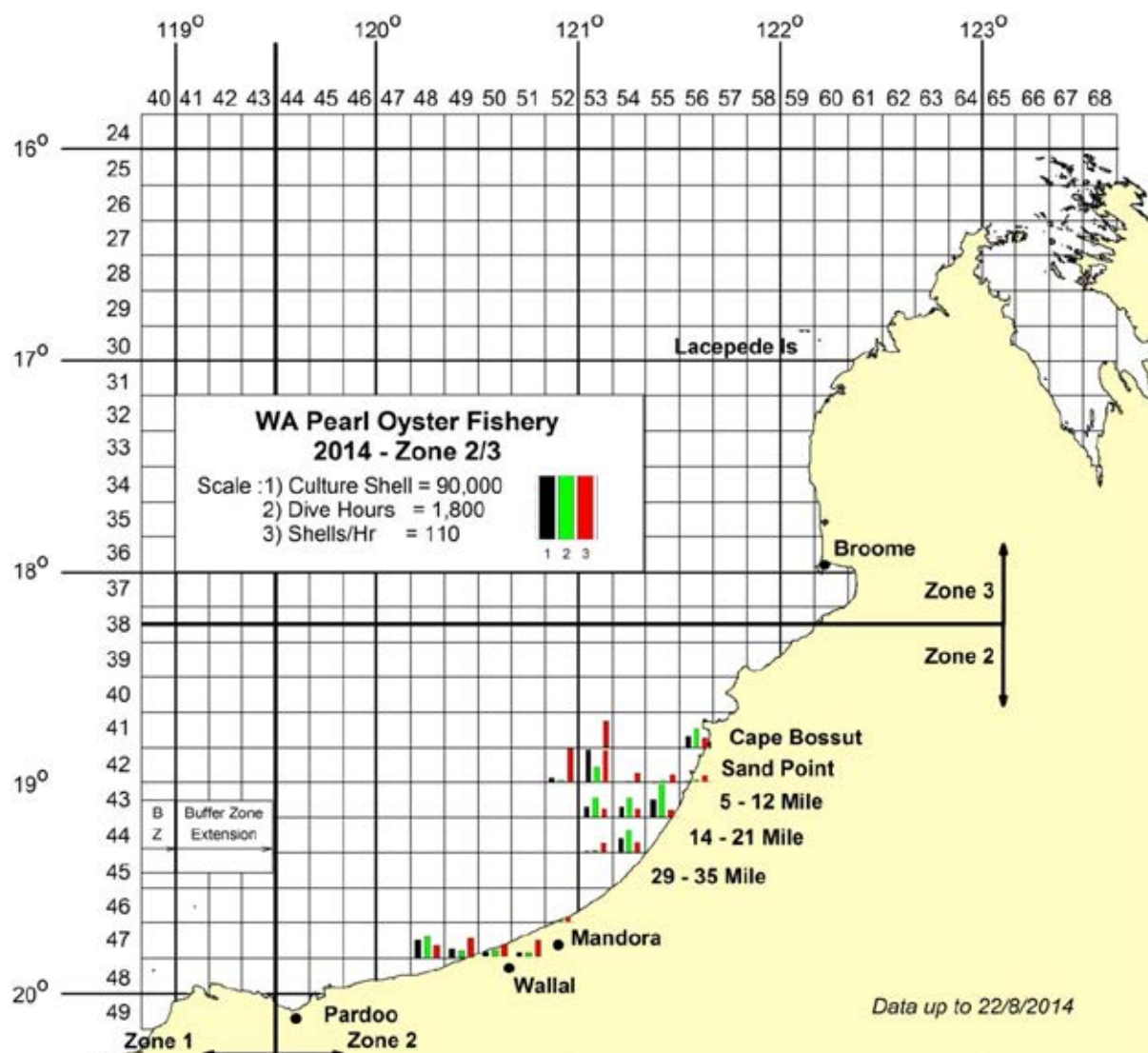


Figure 6.1. Spatial distribution of catch, effort and catch rates in 2014 for *Pinctada maxima* in Zone 2 and Zone 3 of the Pearl Oyster Fishery.

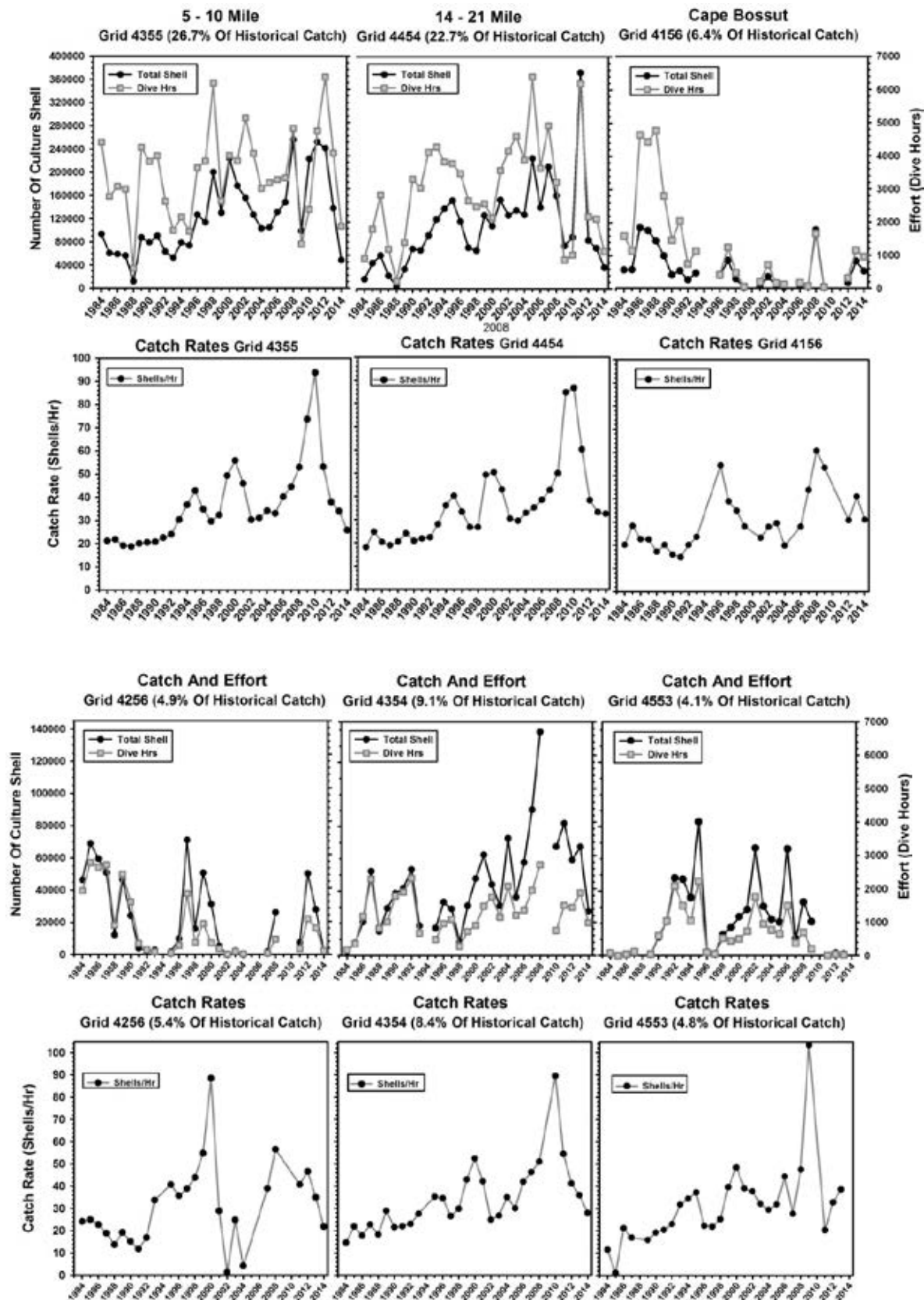


Figure 6.2. Long term trends in catch (total pearl oysters), effort (Dive Hrs) and catch rates in the six highest producing statistical grids in the pearl oyster fishery.

6.1.1.2 Standardisation of annual catch rate

Commercial catch rate data collected from the daily catch and effort logbooks provide a complete coverage of the POF (see Section 7.4). The data are standardised using a generalised linear model to account for the effects of year, visibility, vessel, neap, grid, depth, and experience (of pearl divers). The resultant model (see below) is applied to the individual pearl drift (dive) catch rate data. Each pearl drift is undertaken by between 4 and 8 pearl divers of varying experience for a period of 30 – 60 minutes, depending on depth.

$$\log_e (U_{i,j,k,l,m,n,p} + 1) = \alpha_i + \beta_j + \gamma_k + \delta_l + \tau_m + \phi_n + \varpi_p + \varepsilon$$

where

$U_{i,j,k,l,m,n,p}$ is the CPUE (oysters/hour) for year i , visibility j , vessel k , neap l , statistical grid m , depth n , and experience p .

α_i is fishing year $i \in (2003-2014)$

β_j is visibility $j \in (1, 2, 3, 4, 5, \geq 6 \text{ m})$

γ_k is vessel $k \in (12 \text{ vessels})$

δ_l is neap $l \in (15 \text{ neaps; } \sim 2 \text{ per month})$

τ_m is statistical grid $m \in (22 \text{ grids})$.

ϕ_n is depth $n \in (10 - 12; 12 - 14; 14 - 16; 16 - 18; \geq 18 \text{ m})$

ϖ_p is average experience $p \in (< 51; 51 - 100; 101 - 150; 151 - 200; 201 - 300; \geq 300 \text{ days})$

As the datasets are unbalanced (unequal numbers of replicates per treatment), Type III sums of squares are used and least-square means (as opposed to arithmetic means) are presented. Back-transformed least-square means are calculated to obtain standardized estimates for the CPUE for each fishing year.

The catch rate standardisation model is undergoing continual review and evaluation to account for any changes that affect the usefulness of the SCPUE as an index of abundance. For example, from 2011 the POF implemented an experimental trial of a smaller legal minimum length (LML), a reduction from 120 mm SL to 100 mm SL. On-board monitoring of catch length-frequency (see Section 7.4.2.5.1) established the % of pearl oysters (14%, 17%, 14%, and 6% for 2011 -2014 respectively) harvested that were below the previous LML of 120 mm. Consequently a correction for this management change had to be made to the SCPUE for those years to ensure they were compatible with the earlier years.

Annual trends in the SCPUE index are provided in Figure 6.3 and compared with raw CPUE. The deviation between the two trends in 2014 is due primarily to the fact that 50% of the

catch either came from newly discovered grounds (Shoonta: 20% of catch) or lightly exploited old grounds (Compass Rose: 30 % of catch), which had a substantially higher CPUE than that found in the centre of the fishery.

A comparison of overall spatial difference in standardised CPUE provides good evidence that “Shoonta” and “Compass Rose” pearl patches are the least exploited (highest catch rates; Figure 6.4).

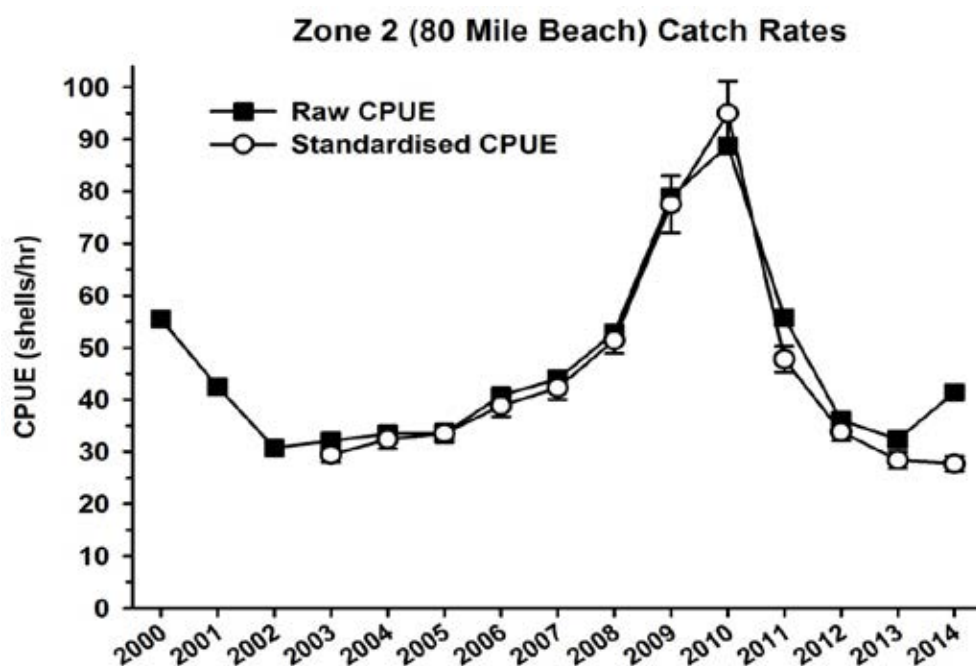


Figure 6.3. A comparison of standardised catch rates and raw catch rates in Zone 2 of the POF.

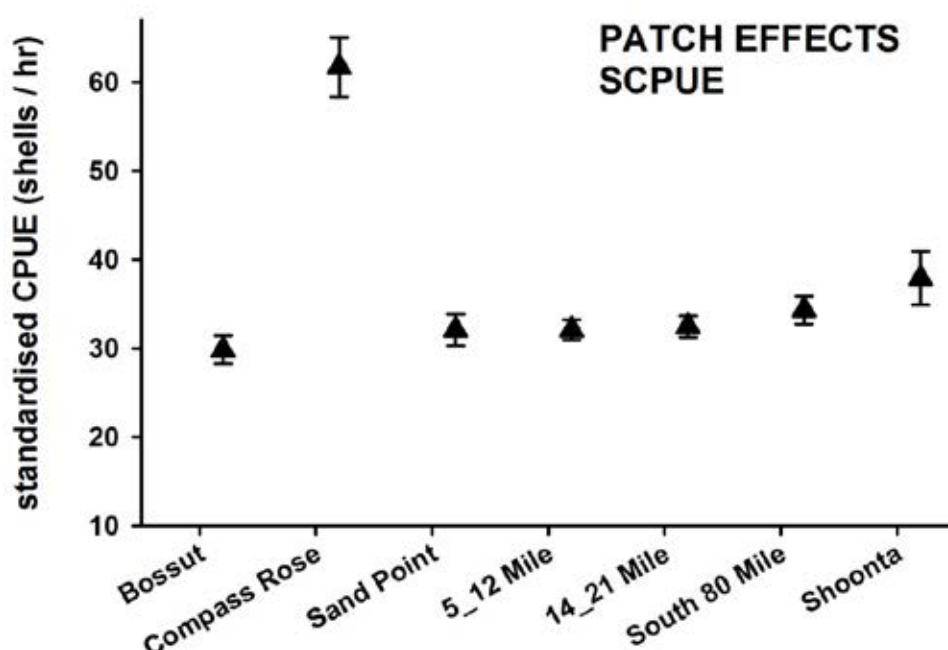


Figure 6.4. A comparison of standardised catch rates from the main fishing grounds (pearl oyster “patches”) of the Zone 2 pearl oyster fishery (averaged over 2003 – 2014).

6.1.1.3 Catch length frequency analysis

Mean size of pearl oysters caught was 154 mm SL in 2014 (Figure 6.5). Average size varied between 126 mm SL at the 29 – 35 Mile (Figure 6.6) and 157 mm at Compass Rose (Figure 6.5). Overall, the length-frequency charts show that fishing was on older stocks than normally occurs. For example the long term trend in average size of *Pinctada maxima* caught in the Zone 2 of the POF shows that 2014 is the highest in the 10 year trend (Figure 6.7). This is indication of lower recruitment into the POF in 2013 and 2014. In contrast, average size caught between 2009 and 2011 was 20 mm smaller than in 2014.

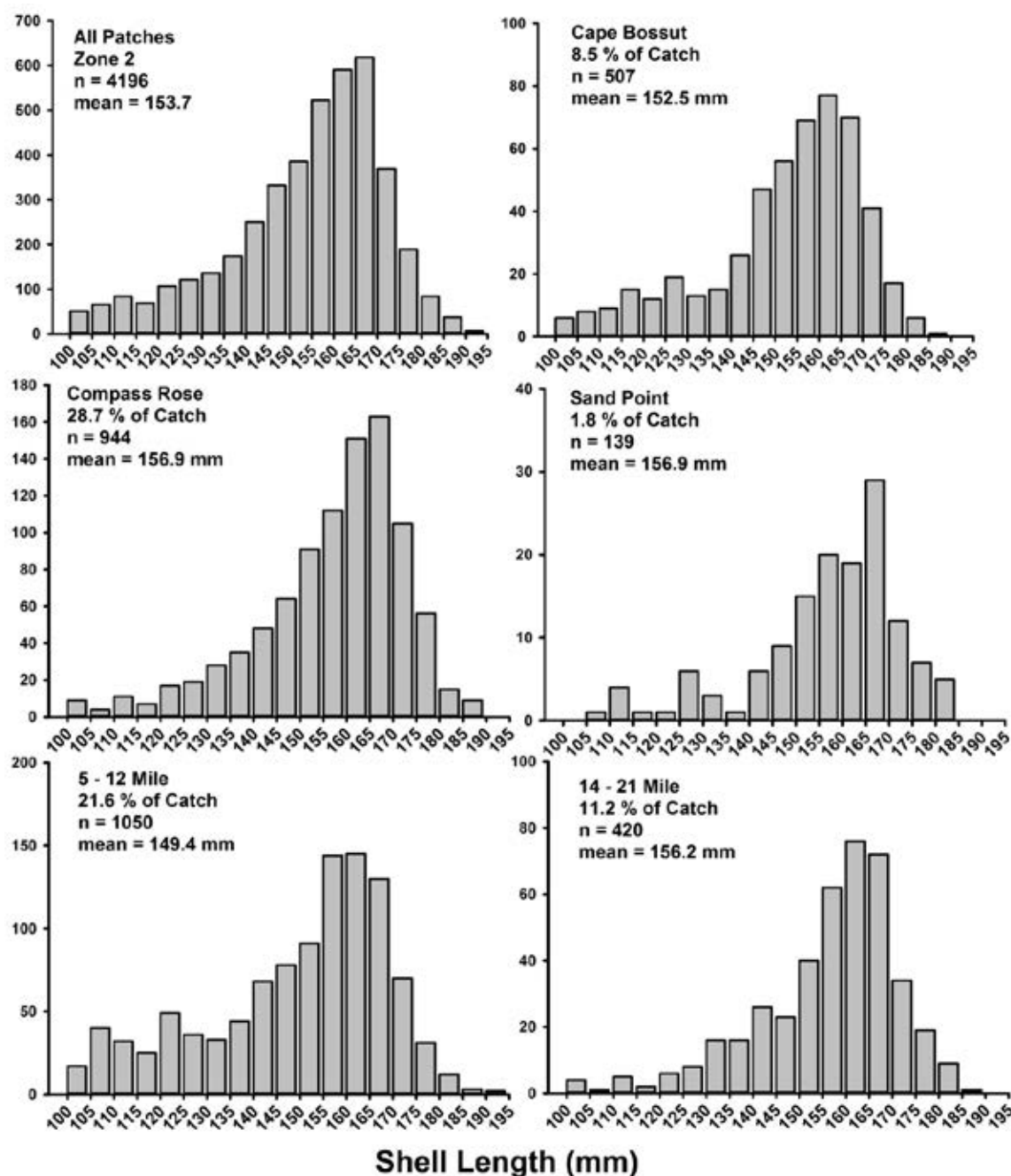


Figure 6.5. Catch length frequency of *Pinctada maxima* from the 2014 'culture' component of the POF, for the whole fishery and individual pearl oyster "patches" (6% less than 120 mm).

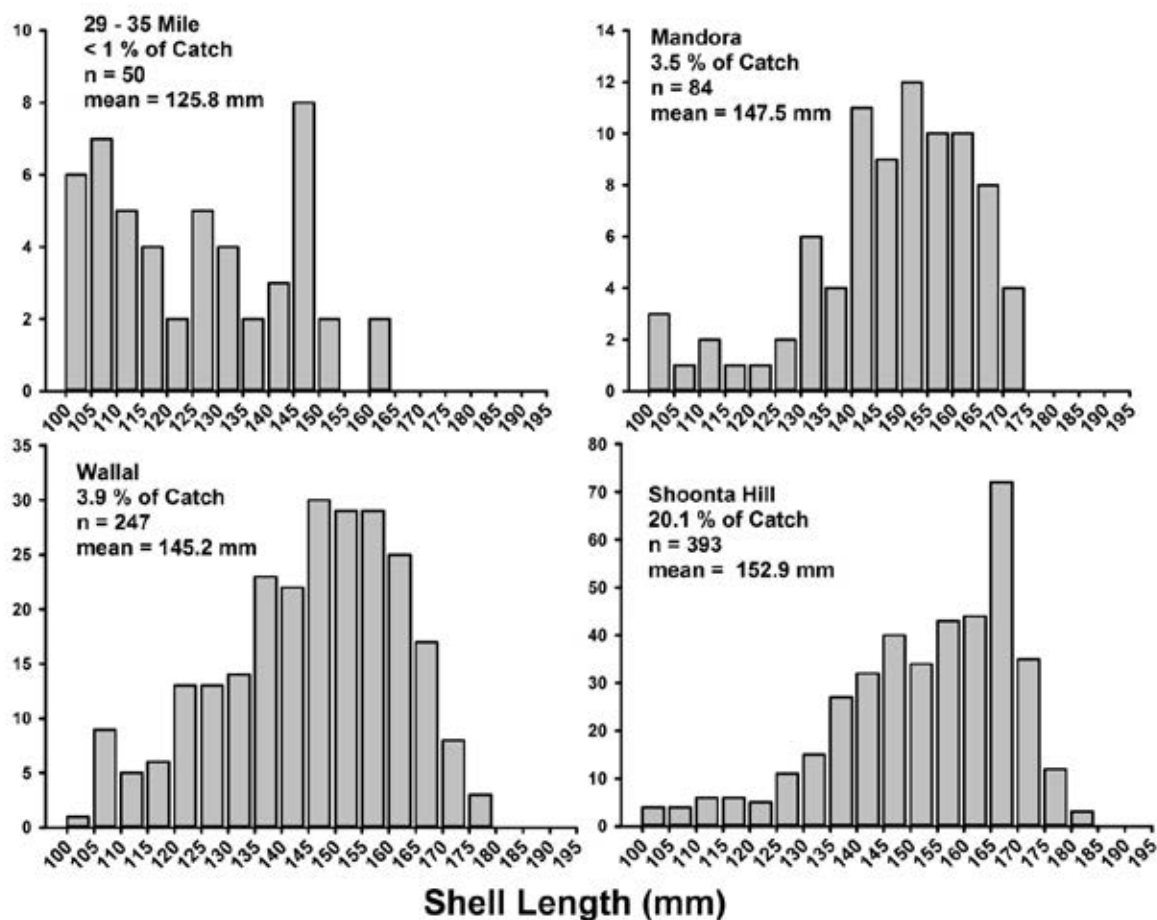


Figure 6.6. Catch length frequency of *Pinctada maxima* from the 2014 'culture' component of the POF, for individual pearl oyster "patches" in the south of 80 Mile Beach. 'Shoonta Hill' has not been fished since 1995.

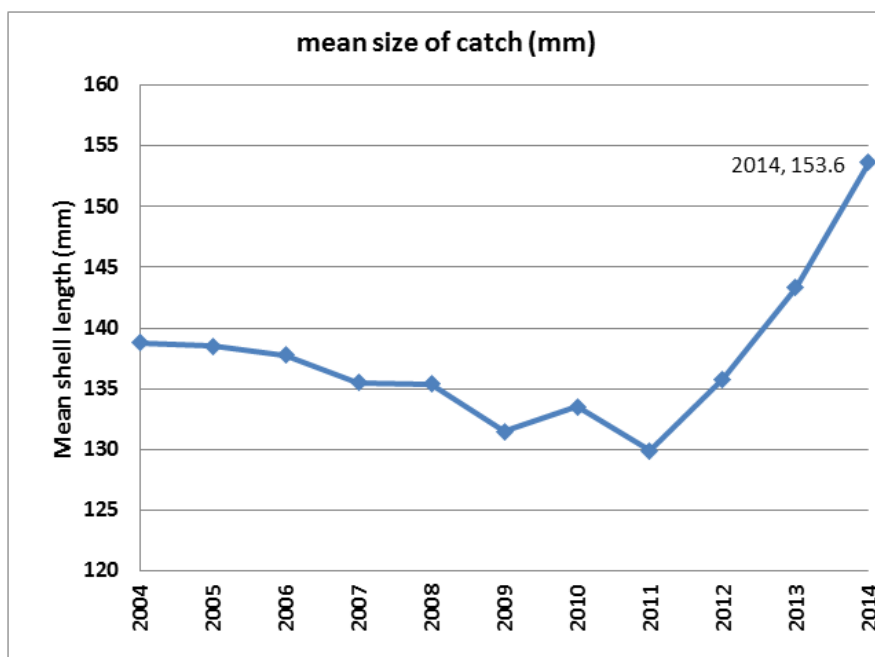


Figure 6.7. Long-term trends in average length of pearl oysters in the POF

6.1.1.4 Population length frequency analysis

Between 2009 and 2014, the population structure of *P. maxima* varied significantly within the 80 Mile Beach stocks (Figure 6.8). In 2009 it was entirely composed of new recruits (120-175 mm SL; ‘culture’) and pre-recruits (< 120mm SL; ‘chicken’). By 2014 the length-composition was predominantly culture pearl oysters (100-175 mm SL) and larger-sized oysters (>175 mm SL) (Figure 6.8). This shift in population length-frequency is entirely consistent with the record recruitment of 2005; these pearl oysters would have “grown” into the POF in 2009 and joined the larger-size class in 2012-2014. Additionally in 2014, previously lightly exploited stocks with a large residual biomass (Compass Rose and Shoonta Hill) were fished, which accounted for a proportion of the large oysters collected.

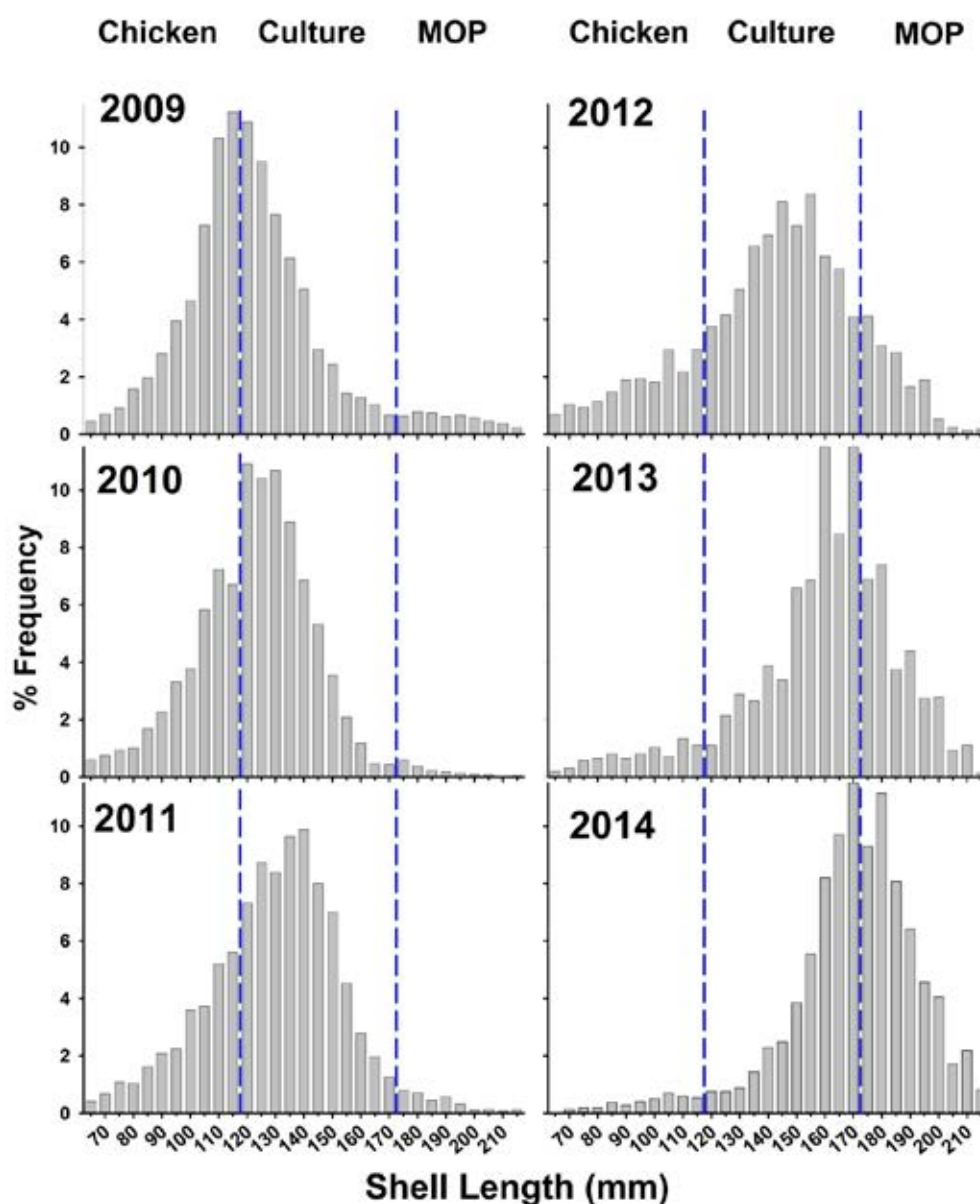


Figure 6.8. Population length frequency of *Pinctada maxima* from surveys in the Zone 2 fishery between 2009 and 2014.

6.1.1.5 Population surveys: Long-term abundance of ‘chicken’ (< 120 mm) and ‘culture’ (120 – 175 mm) sized oysters

Longer-term trends in the standardised research survey of pre-recruits show that the period from 2007 to 2011 had a significantly higher abundance than the years 2001, and 2012 to 2014 (Figure 6.9). There was a very slight increase in 2014, up from 2013, however the effect is unlikely to show up in the recruited size class. In comparison the recruited size-class shows more of a gradual increase from 2007 to 2011 before a sharp decline in 2014 (Figure 6.9). The spat settlement index (Figure 6.11) suggests some minor increases in pre-recruits should be expected in 2015, and then followed by recruitment into the POF.

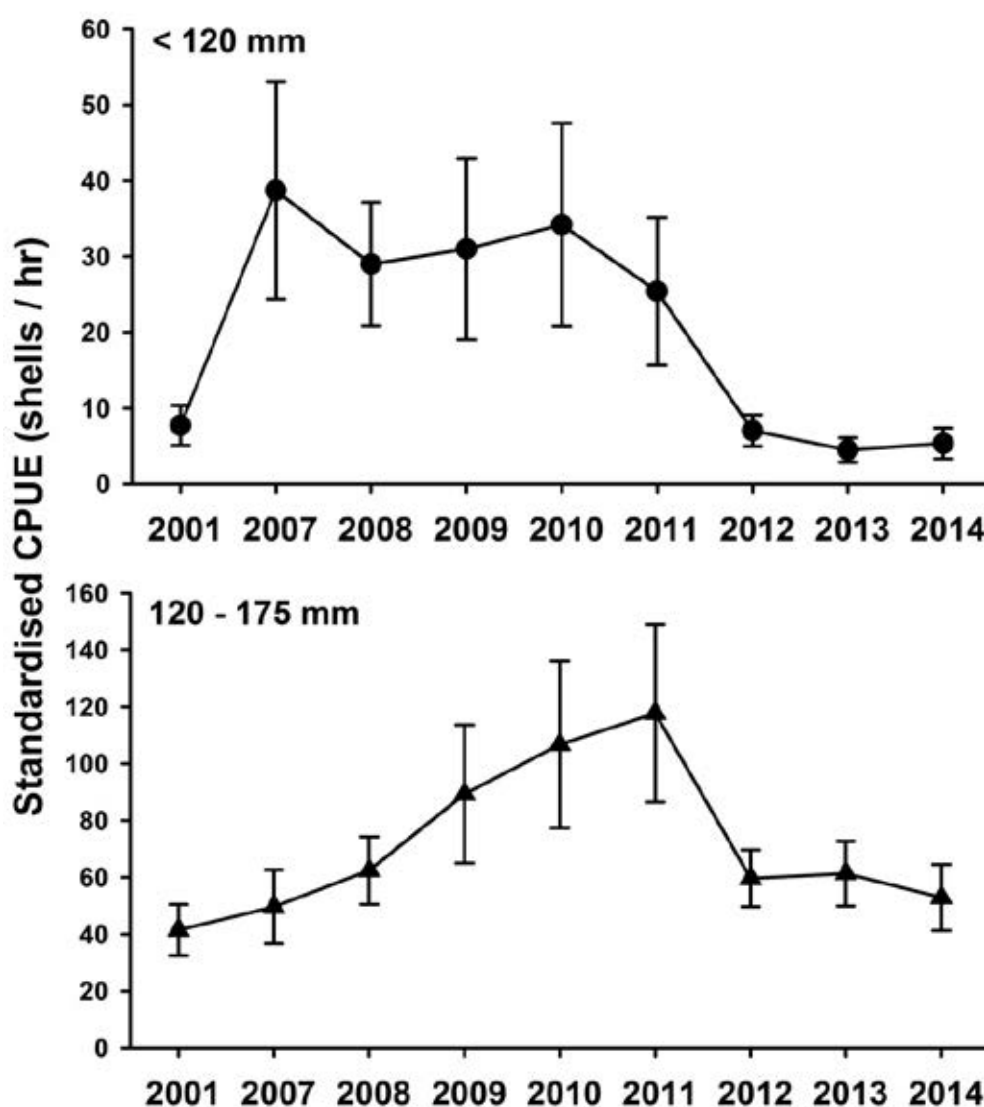


Figure 6.9. Standardised abundance (oyster caught per hour; \pm CL) of pre-recruit (<120 mm) and recruited (120 – 175 mm) *Pinctada maxima* in the Zone 2 Pearl Oyster Fishery between 2001 and 2014.

6.1.1.6 Spat settlement length frequency (2008 to 2014)

Between 2008 and 2014 the spat settlement surveyed detected two clear age classes, Age 0+ and Age 1+ (Figure 6.10). In general these could be assigned adequately to two size classes, 0 – 35 mm being Age 0+ and 35 – 70 mm being Age 1+. The 2008 and 2010 years displayed the clearest examples of this age/size distribution (Figure 6.10). However, a late 0+ settlement in 2013, which resulted in a higher percentage of pearl oysters being measured ($50\% < 15$ mm), coupled with an early Age 0+ settlement in 2014 ($25\% < 15$ mm) meant that there was only a 15 mm difference between the Age 0+ and Age 1+ modes in 2014 (Figure 6.10). These annual variations in settlement timing are accounted for in the standardised index model which selects the most appropriate size classes to assign to age cohorts.

6.1.1.7 Standardisation of annual pearl oyster settlement index

Pearl oyster recruitment is measured by the ‘piggyback spat’ settlement index as measured by the annual monitoring program (see Section 7.4.2.5.3). The data are analysed using a GLM accounting for year, neap, patch, and depth. The resultant model is:

$$\log_e (U_{i,j,k,l} + 1) = \alpha_i + \beta_j + \gamma_k + \delta_l + \varepsilon$$

where

$U_{i,j,k,l}$ is the 0+ spat settlement rate (number /1000 adults) for year i , neap j , patch k , and depth l .

α_i is fishing year $i \in (2000-2014)$

β_j is neap $j \in (10 \text{ neaps; } \sim 2 \text{ per month})$

γ_k is patch $k \in (5 \text{ patches; a pearl oyster “patch” is a spatial area})$

δ_l is depth $l \in (<10, 10 - 12; 12 - 15; 15 - 18; \geq 18 \text{ m})$

As the datasets are unbalanced (unequal numbers of replicates per treatment), Type III sums of squares are used and least-square means (as opposed to arithmetic means) are presented. Back-transformed least-square means are calculated to obtain standardized estimates for the CPUE for each fishing year.

Annual trends in the 0+ spat settlement index are provided in Figure 6.11.

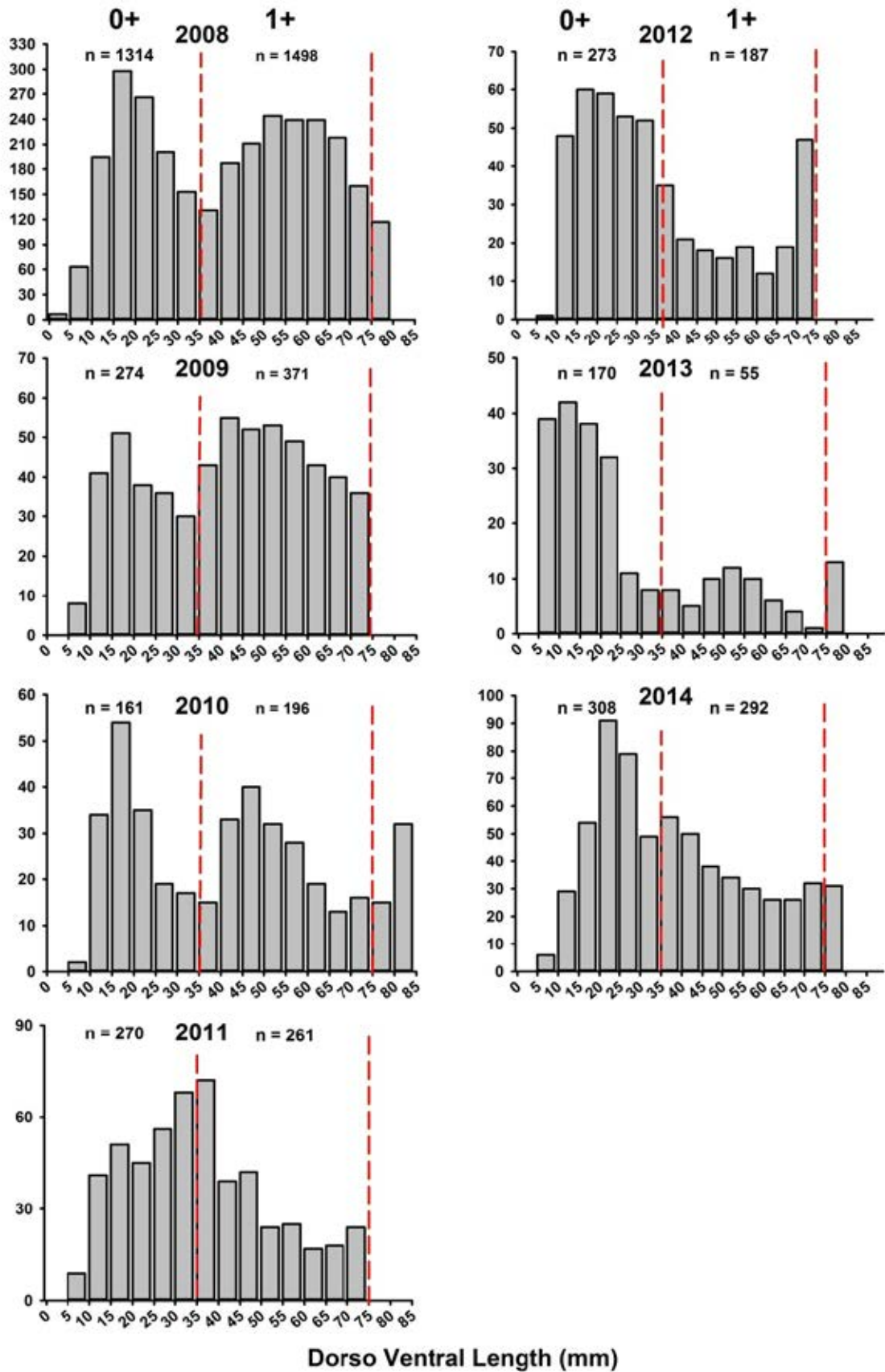


Figure 6.10. Length frequency distribution of newly settled *Pinctada maxima* (Age 0+, 1+) between 2009 and 2014.

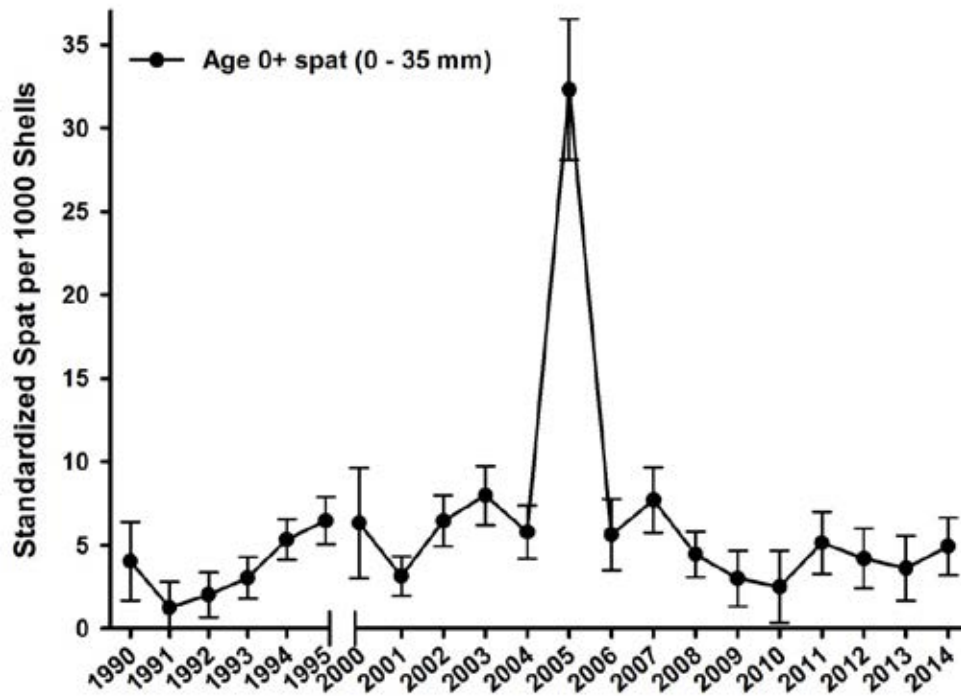


Figure 6.11. Standardised 0+ spat abundance (per 1000 adult shells; \pm CL) in the Zone 2 Pearl Oyster Fishery.

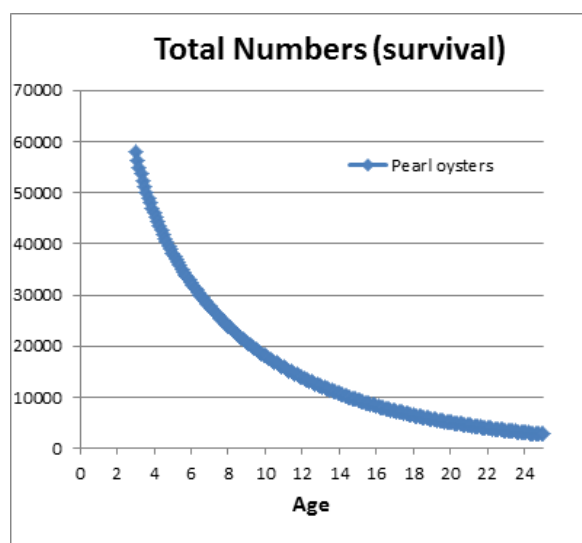
6.1.1.8 Prediction of “exceptional” settlement years: a spawning per recruit perspective

The presence of one clear mode of exceptional settlement in the spat index data (2005; Figure 6.11) and three clear modes in the catch rate data (95/96, 00/01, 09/10; Figure 7.4) is suggestive of a cyclical nature to ‘exceptional’ settlement possibly linked to the actual event itself. This is considered a plausible hypothesis due to reproductive expression of protandrous hermaphroditism within this species.

To examine the relative contributions of male and female gonads from each age group for a given recruitment, a per-recruit modelling study was undertaken using the relationship between size and sex (Figure 3.3) combined with growth (Figure 3.7), length-gonad relationships, and survival rates.

Following the survival of a cohort of 60,000 pearl oysters beginning at Age 3 when males start to mature (Figure 6.12a), it can be seen that the male reproductive output is maximised very quickly at around Age 5 and for a relatively short time period of 5 years (Figure 6.12b). In contrast, female reproductive output is not maximised until Age 10 - 12, and the effort is spread over a larger part of the cohorts’ reproductive life (Figure 6.12b). Given the strength of the 2005 cohort, it can be reasonably inferred that from 2015 to 2018, there will be a substantial increase in females adding to the reproductive effort of the population as that cohort grows into its peak female maturity. If combined with favourable environmental conditions, it could lead to another large settlement.

(A)



(B)

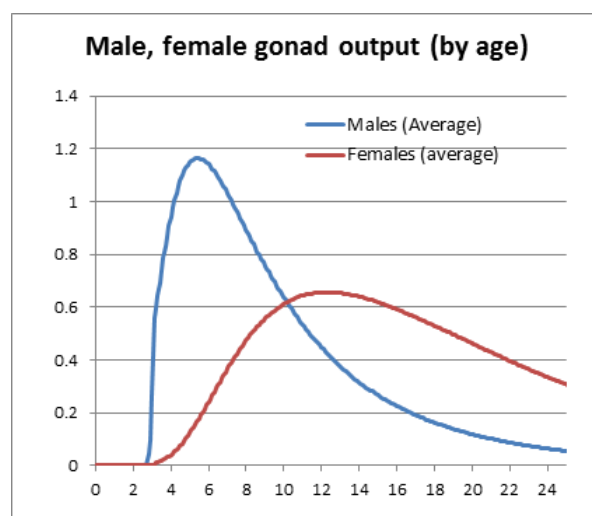


Figure 6.12. (a) Survival curve of pearl oysters in the wild (unfished trajectory); (b) relative reproductive output of each sex (males, females) from a cohort of oysters throughout its life (assumed maximum age = 25 years).

6.1.1.9 Prediction of future catch rate

A multiple regression analysis predicts future catch rates based on trends in the Age 0+ spat settlement, so as to provide informative data for determining the SHL and recommending a TAC (Figure 6.14). The analysis is updated each year as more data become available, and the model incorporates the contribution of two different year classes (recruitment cohorts) to the available stock for harvest. The current equation (2014) for the stock prediction model is as follows.

$$SCPUE_n = 1.48(0+)_{n-4} + 2.09(0+)_{n-5} + 18.95; r^2 = 0.95$$

where $SCPUE_n$ is the abundance of pearl oysters (120 – 175 mm) in the harvest year n ; $(0+)_{n-4}$ is the spat abundance in year $n - 4$, and $(0+)_{n-5}$ is the spat abundance in year $n - 5$.

Because of its high explanatory power ($r^2 = 0.95$), the predictive model is also used to provide an early warning system for the harvest control rule as it provides predicted estimates of SCPUE 4 years in advance. It used to estimate whether the stock abundance may be approaching the threshold and limit reference points for SCPUE, thus allowing for pre-emptive management action.

A graphical representation of the stock prediction model indicates that abundance is predicted to be similar in 2015 and increase in 2016 (Figure 6.14). For comparative purposes, the stock prediction model from 2012 is also shown (Figure 6.13). The new 2014 model includes data from the 2013 and 2014 seasons. The declines in SCPUE predicted by the 2012 model were realised.

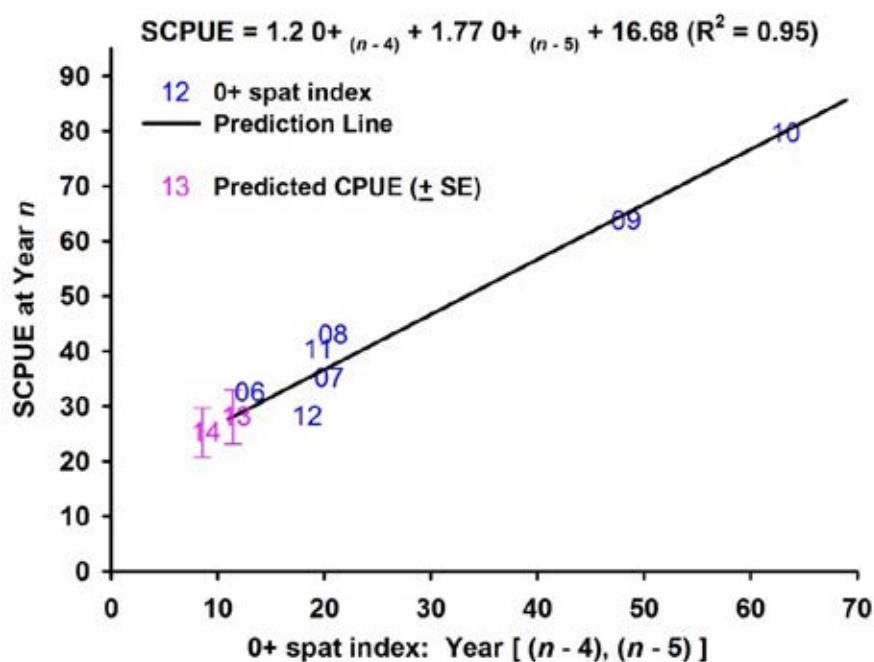


Figure 6.13. 2012 forecast model: abundance (SCPUE) of *P. maxima* in the Zone 2 fishery in year n , expressed as function of 0+ spat settlement. The prediction line is an expression of the formula at the top. Blue numbers are the data for year of the SCPUE (12 = 2012), pink numbers are the predicted abundance (\pm SE) for future years (13 = 2013; 14 = 2014).

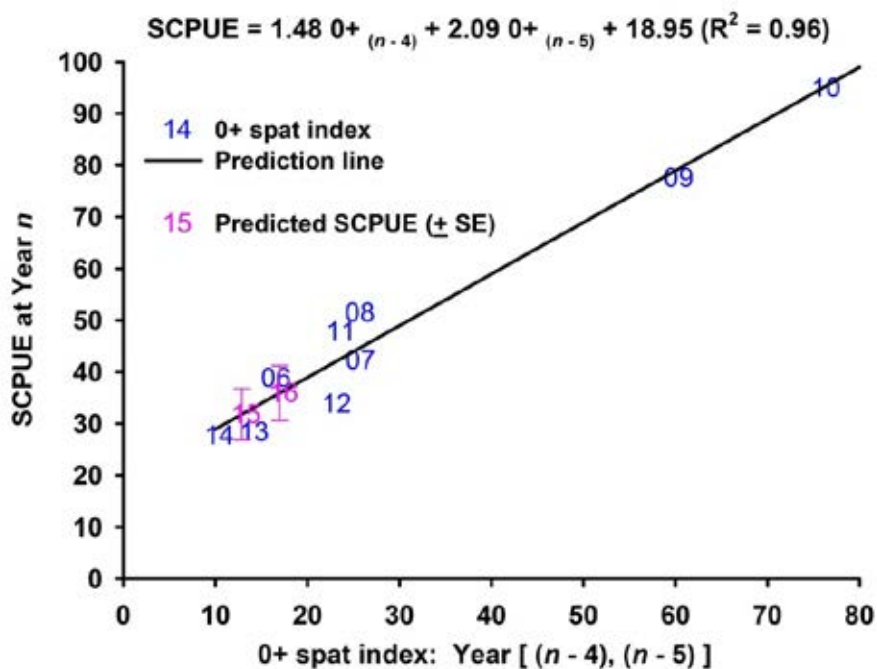


Figure 6.14. 2014 forecast model: abundance (SCPUE) of *P. maxima* in the Zone 2 fishery in year n , expressed as function of 0+ spat settlement. The prediction line is an expression of the formula at the top. Blue numbers are the data for year of the SCPUE (12 = 2012), pink numbers are the predicted abundance (\pm SE) for future years (15 = 2015; 16 = 2016).

6.1.2 Assessment of larger pearl oysters (>175 mm SL)

6.1.2.1 Map of survey areas

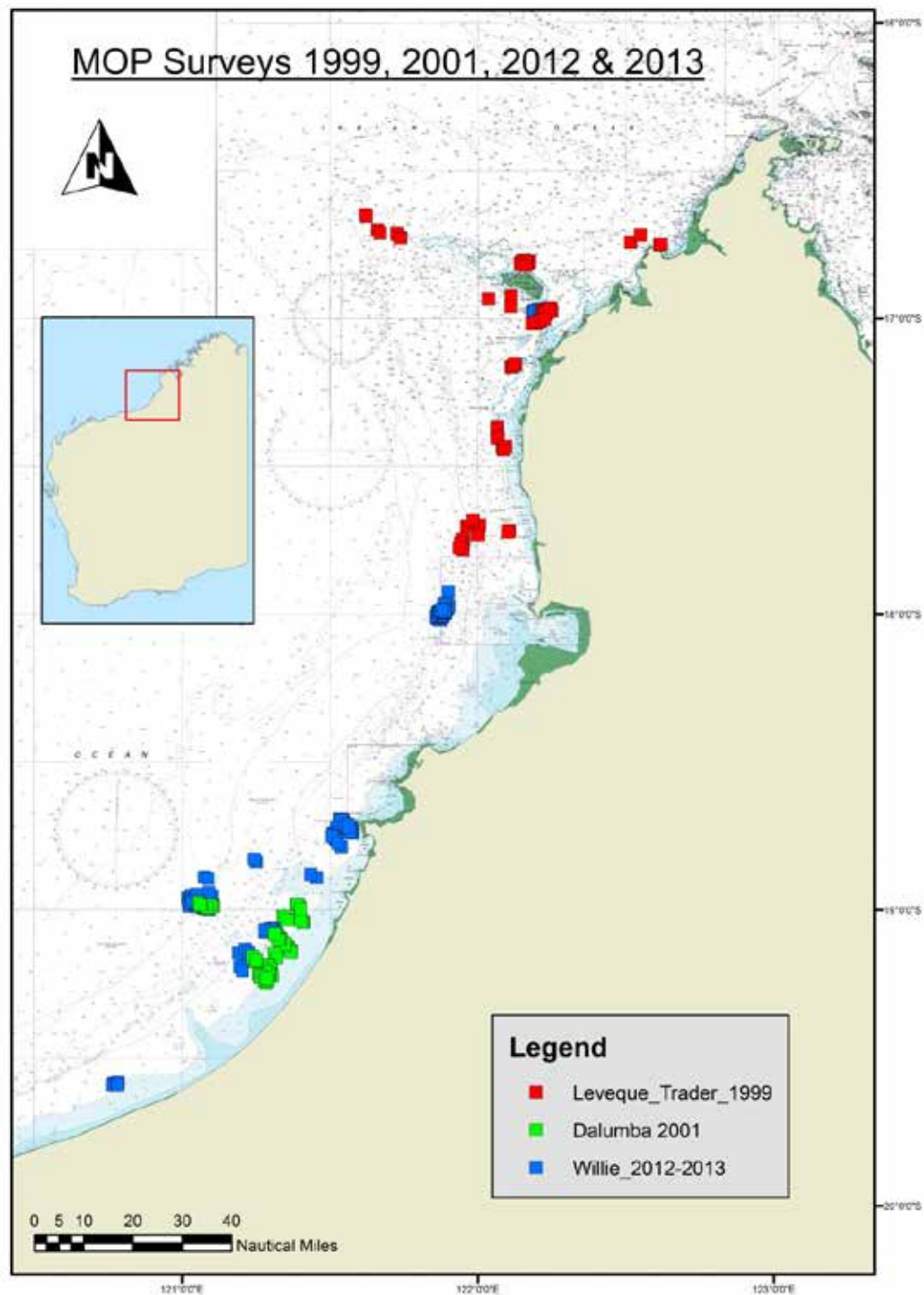


Figure 6.15. Spatial location of areas surveyed for larger sized shell (>175mm) abundance in 1999, 2001 and 2012/13.

6.1.2.2 Spatial catch and effort

Fishing effort on larger pearl oysters (>175 mm SL) for the purposes of collecting MOP was carried out between 2011 and 2014, with the majority of effort occurring in 2012 and 2013. The total catch that came out in 2012/13 was 265,000 larger pearl oysters with a dive effort of 3,020 dive hrs and an overall catch rate of 88 pearl oysters / hr (Figure 6.16).

The Compass Rose patch sustained the greatest harvest of larger oysters for MOP, followed by Cape Bossut and Gantheume (Figure 6.16).

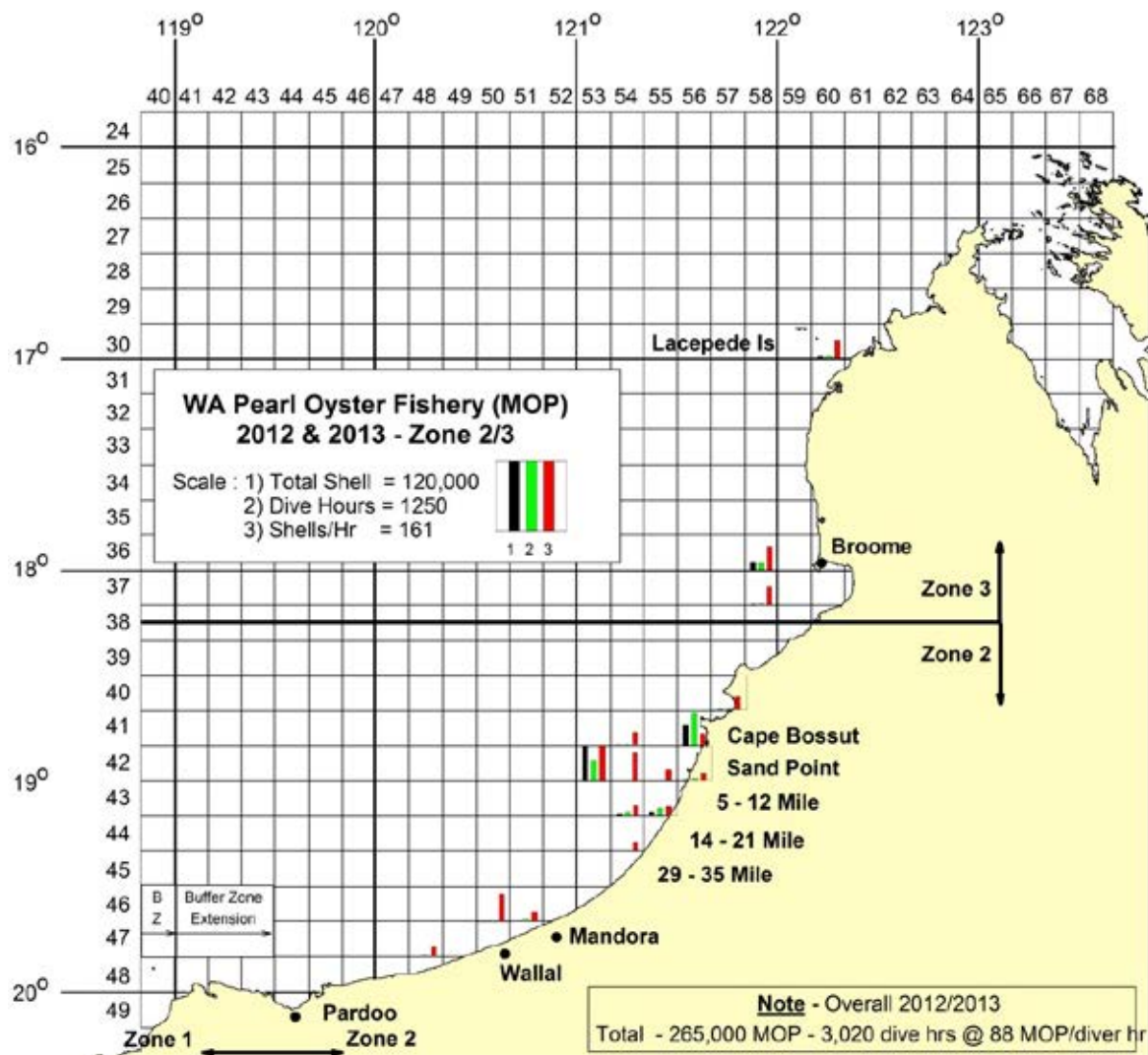


Figure 6.16. Spatial distribution of catch, effort and catch rates of larger pearl oysters (>175mm) used for Mother of Pearl (MOP) in Zone 2 during 2012 and 2013.

6.1.2.3 Spatial variation in length frequency of larger *P. maxima*

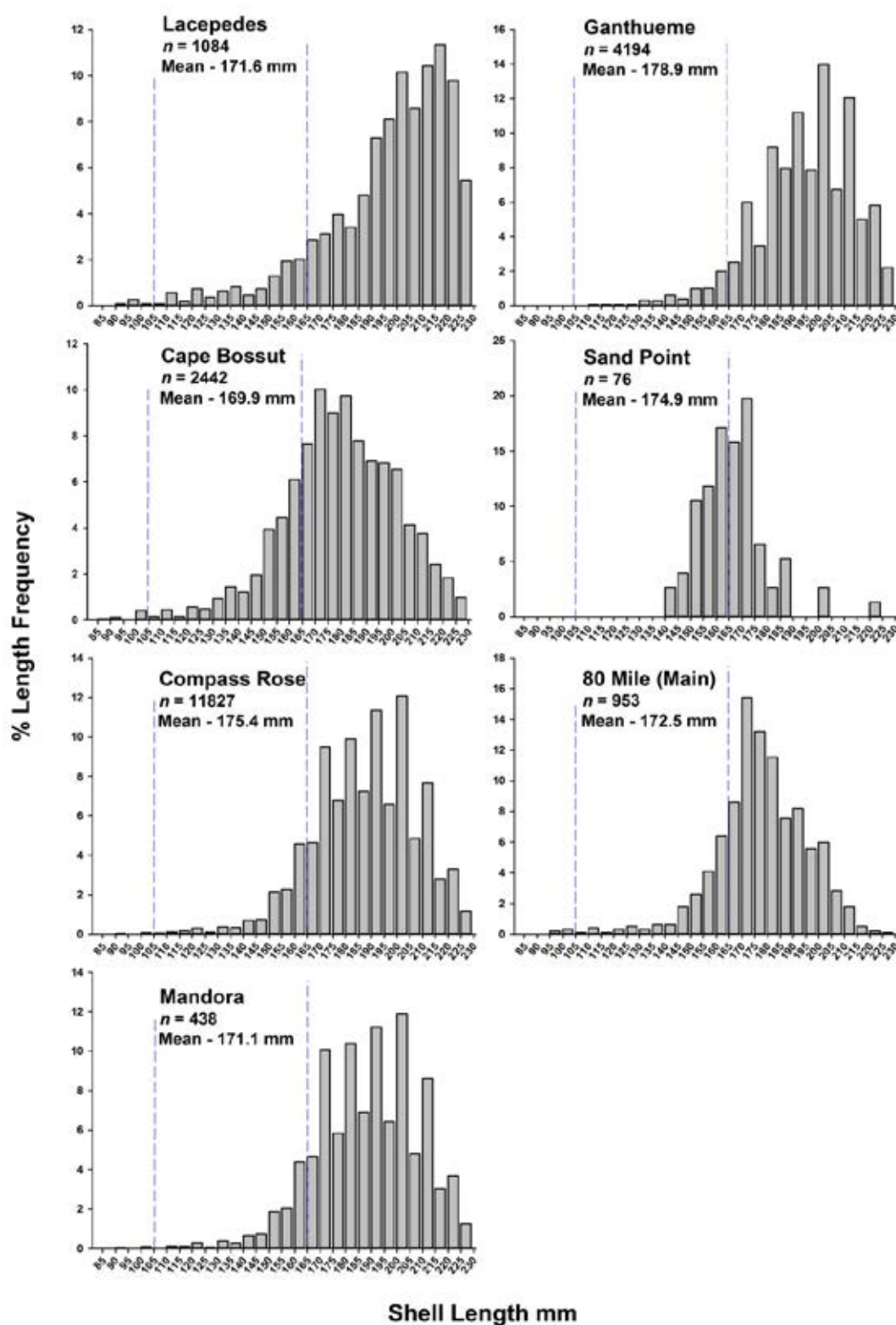


Figure 6.17. Spatial variation in length frequency of larger pearl oysters from research surveys in Zone 2 of the POF

6.1.2.4 Population surveys on larger *P. maxima* (>175 mm SL)

There are two indices for abundance of pearl oysters > 175 mm SL in the POF. The first index is derived from dedicated surveys for these pearl oysters in areas known to hold the greatest quantity. These were carried out in 2001 and then in 2012 and 2013 (blue circles; Figure 6.18, see also Figure 6.15 for survey locations).

The second index is that derived from annual research surveys carried out as part of the analysis of the 'culture' component of the POF. These surveys have been undertaken since 2007 by pearl oyster divers, under the supervision of Departmental personnel (black squares; Figure 6.18). These surveys are generally spatially separated from the dedicated surveys on larger shells. Together both surveys give reasonable coverage of the majority of the pearl oyster stocks.

Both indices suggest abundance of pearl oysters greater than 175mm SL has increased since 2001.

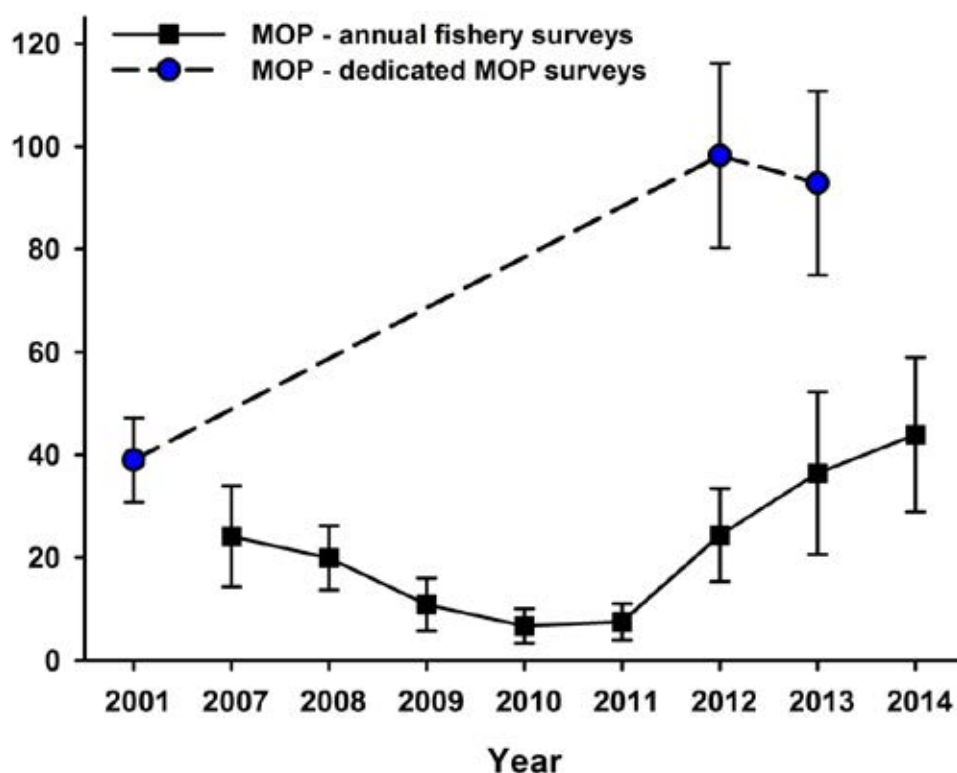


Figure 6.18. Standardised catch rates (oyster caught per hour; \pm CL) of larger sized pearl oysters (> 175 mm) used for Mother of Pearl (MOP) in the Zone 2/3 POF between 2001 and 2014.

6.1.2.5 Sustainable Harvest Levels (SHLs) for larger *P. maxima*

In 2011 to 2014, a total of 320 population survey drifts were undertaken over the main fishing grounds (Table 6.1). Catch rate data from these was combined with estimates of the spatial area of the main patches, and knowledge of the fishing efficiency of divers, to arrive at estimates of total population numbers of larger *P. maxima* (Table 6.1). These were then used to calculate sustainable harvest levels, using a similar analysis as that carried out by Hart and Friedman (2004). The two formulas for estimating SHLs are as follows:

$$SHL_{LIMIT} = M \times \beta_{population} ; SHL_{TARGET} = 0.66M \times \beta_{population}$$

Where M is natural mortality (assumed at 0.15) and $\beta_{population}$ is the population estimate. The limit SHL represents the maximum allowable catch, whereas the target is the more conservative harvest rate.

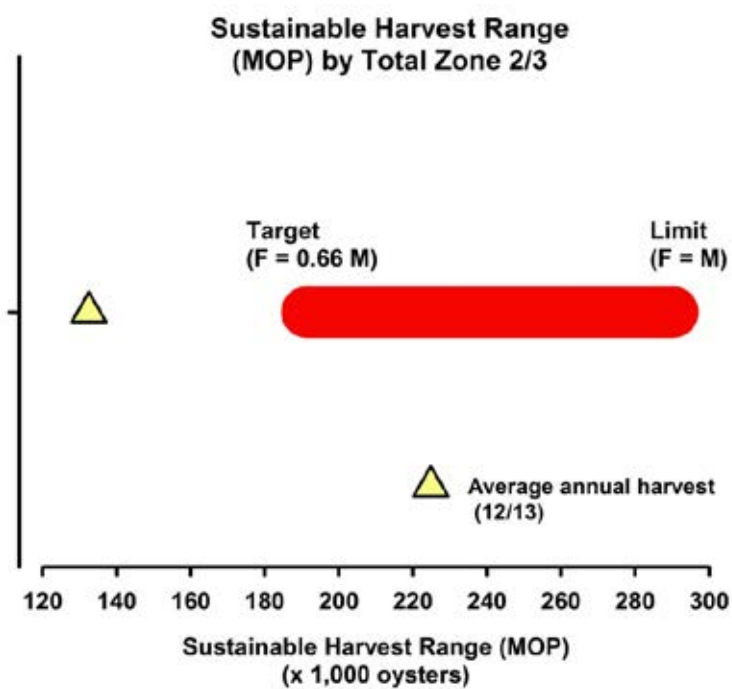
Estimated sustainable harvest in Zone 2/3 varied between 190,000 and 300,000 larger pearl oysters (Figure 6.19a). Looking at individual fishing areas, it can be seen that Compass Rose contains by far the most significant population of larger pearl oysters, followed Gantheume (Figure 6.19b). At current rates of harvest, Compass Rose is fully exploited, whereas at Cape Bossut catches have been higher than the estimated SHLs. Other areas are lightly exploited (Figure 6.19b).

These estimates of SHLs are based on a conservative estimate of total fishing area of 145 km². Previous estimates of fishing area have been as high as 200 km².

Table 6.1. Spatial estimates of area of fishing grounds (Location), number of survey drifts undertaken, mean densities, and total population estimates of pearl oysters > 175 mm SL in Zone 2/3 of the POF.

Location	Total area (km ²)	Survey drifts	Mean density (per km ²)	Total population
Lacepedes	6.012	82	24910	177667
Bossut	9.2484	40	18031	155838
Sand Point	2.9772	10	5720	15151
5-8 Mile	20.736	11	9030	160274
10 Mile	17.9028	41	10185	161566
14-21 Mile inside	24.0372	29	9423	189619
South 80 Mile	15.4692	18	12970	166381
Shoonta and Wallal	7.48	8	16846	98766
Compass Rose	30.86	43	18031	520001
Gantheume	9.9	38	23373	288838
Total	144.6228	320		1934101

(A)



(B)

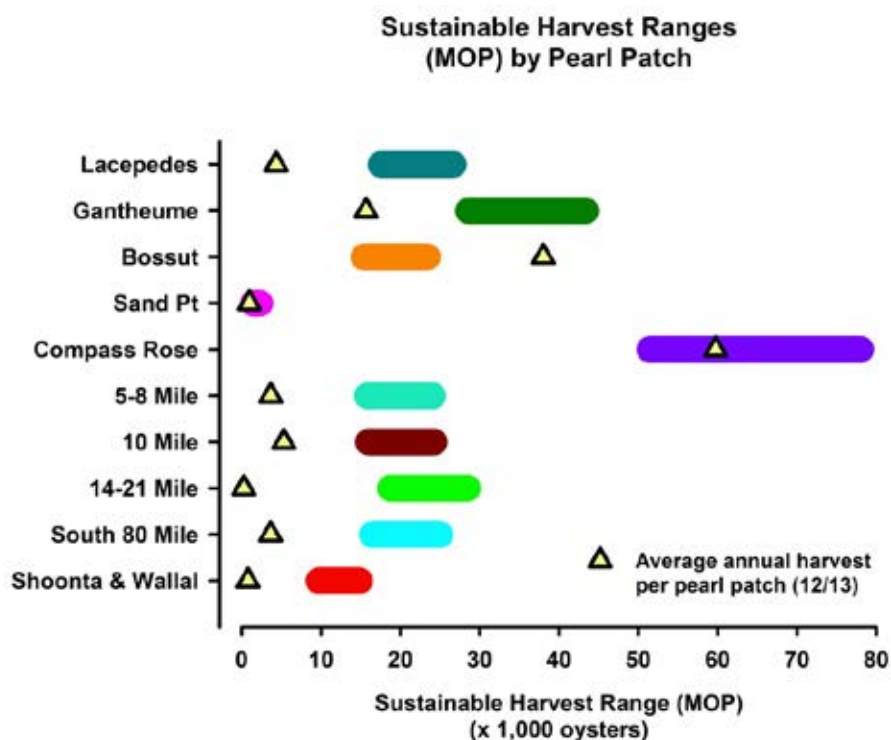


Figure 6.19. (A) Total SHL range for larger pearl oysters used for Mother of Pearl (MOP) (B) SHL range by the major fishing grounds. The yellow triangles are the average annual harvest for the 2012/2013 fishing years.

6.1.3 Appropriateness of assessment

The indices and associated reference points used in the assessment are appropriate for the control rules applied in the POF, i.e. based around modifying the SHL (and ultimately the TAC) when indicators are below the specified and proposed reference points for effort, catch rate, and recruitment (see Section 7.2). Each year the assessment of current abundance (from annual catch rates) and future abundance (from the prediction model) is used to recommend an appropriately conservative SHL.

A stock assessment is thus undertaken every year to determine whether the current abundance of the stock is above the threshold and limit reference points and, as described above, to recommend an appropriate SHL for the next season.

In addition, the assessment takes into account the major features relevant to the biology of the species and the nature of the POF. For example, with respect to biology, sedentary invertebrate species, including *P. maxima*, are known to experience large fluctuations in recruitment, such as occurred in 2005 when there was an exceptionally strong recruitment of this species. As a result of the predictive model, management was able to adapt to this change allowing licence holders to take economic advantage of this year class when it recruited into the POF. Note that the predicted large increase in recruitment from the 2005 cohort was entirely realised in the 2009 to 2011 fishing years (Figure 7.1). As no further exceptional recruitments have occurred, the SHL has been dropped back to normal levels as is appropriate for the stock.

With respect to the POF, the pearl oysters that are harvested are almost entirely young, fast-growing males (120 – 160 mm) which are ideal for culturing pearls. The current and predicted future catch rates of pearl oysters are mainly focused on animals within this phase of their lifecycle.

As discussed in Section 6.1.2 there is a renewed interest by industry to harvest larger pearl oysters (>175mm) that were voluntarily fully protected between 1987 and 2009. A very precautionary SHL was set for these larger females (noting this species is a protandrous hermaphrodite) based on a detailed assessment of the biomass of the mature stocks of pearl oysters by Hart and Friedman (2004). The full details of the methodology used as a basis for this SHL setting is provided in that reference. Note that the level of SHL applied to larger pearl oysters (>175mm) is highly precautionary and the fishing currently undertaken is at very low levels in comparison to historical levels (pre 2nd World War). The impetus for the study of Hart and Friedman (2004) was to explore the potential to allow the pearl industry to diversify its operations given that the value of pearling has declined in recent decades and that fishing for pearl oysters for MOP production was historically important.

In this assessment, stock status has been evaluated using all of the available data according to appropriate reference points.

6.1.4 Assessment approach relative to reference points

The assessment approach is directly focussed on ascertaining that the stock size is not at risk due to excessive removal by fishing. This is pursued through careful and robust annual assessment of standardized catch rates. See Section 7.2 on limit, threshold and target reference points.

6.1.5 Uncertainty in assessment

The assessment methodology has evolved over time to increasingly account for various sources of uncertainty that impact on the accuracy of the effort, catch rate and recruitment indices. As discussed in Section 6.1.1, the current assessment recognises a range of factors that influence the catch rate and recruitment indices, including fishing areas, depth, visibility, vessel and diver experience. The relative impacts of these factors are routinely explored and accounted for using standardised indices. The overall standardised values are presented with measures of variability (uncertainty) about the estimated mean values (Figure 7.1; Figure 7.9). The possible impacts of different factors are also routinely discussed with the pearling industry at Annual Management Meetings (AMM) and this leads to the ongoing identification of new and important factors. For example, the exploration of visibility began in 2003, after the pearling industry expressed a strong view that this was an important factor affecting catch rates. In 2003, a measurement of visibility for each dive was incorporated into the daily catch and effort logbook and subsequent analysis of these new data confirmed the high importance of this variable and it is now part of the standardised catch rate index (see Section 6.1.1). Similarly, the importance of individual diver experience was identified by the pearling industry in recent years due to substantial loss of experienced personnel and subsequently confirmed using standardisation procedures as part of the assessment.

It is recognised that the indices used for the assessment don't capture all the inherent uncertainties. For example, the precise age structure is not known due to no reliable method for ageing pearl oyster shells, although information are available on growth through tracking of cohorts over time. An understanding of growth, in combination with information on recruitment levels, has however enabled the lag times between recruitment of Age 0+ juveniles and this year class entering the POF to be determined with a reasonable degree of certainty. This is important for assessment of the POF.

6.1.6 Evaluation of assessment

There is strong evidence that the current assessment approach is robust. The robustness of the assessment is tested every year when predictions are made regarding future levels of abundance of the stock, as indexed by future catch rates. For example, following the exceptionally high recruitment detected in the 2005 monitoring, the assessment resulted in a prediction of high catch rates in 2008 to 2011, and this prediction was confirmed (Figure 7.1). Similarly in 2010, a prediction was made of lower abundance (and thus catch rates) for 2011 and 2012 that was subsequently confirmed (Figure 6.13). Importantly, these predictions of reduced abundance resulted in CEO lowering the TAC and providing increased protection for the stock, thereby ensuring that recruitment is not jeopardised by excessive fishing pressure during a time of low natural recruitment. In summary, the assessment approach has been

shown to be reliable and has allowed the development of control rules that ensure management is highly responsive to stock status.

6.1.7 Peer review of assessment

Annual internal reviews are undertaken as part of the process for completing (and updating) the annual Status Reports of the Fisheries and Aquatic Resources in Western Australia.

In recent years, the Department has had a schedule for peer review of assessments for all fisheries; this “rolling” schedule aimed to generate major reviews of 5-8 fisheries per year, employing a mix of internal and external (e.g. universities, CSIRO, inter-state fisheries departments) fisheries experts. This has not been specifically undertaken for the POF because the significant aspects of the work undertaken have been peer reviewed the scientific literature.

The Australian Government Department of the Environment assessed the POF in 2015 as being sustainable under the provisions of the EPBC (see Section 2.5.3). Following this the POF was accredited for export until May 2025.

7. Harvest Strategy

Table 7.1 Summary of reference points, performance measures and control rules for *P. maxima* harvested by the POF

Assessment	Performance Indicators	Reference Levels	Control Rules
Level 4 stock assessment incorporating standardised fishery-dependent relative abundance and fishery-independent recruitment surveys.	Annual standardised commercial catch rate (SCPUE) of culture pearl oysters (120 – 175 mm) in Zone 2/3 of the POF	Target: SCPUE is 25 pearl oysters per hour	Baseline SHL of 54 970 oysters set for Zone 1. SHL for Zone 2/3 calculated a function of stock abundance using predictive model.
		Threshold: SCPUE is 20 pearl oysters per hour	(a) If SCPUE is between the target and threshold level, reduce SHL by 30% below baseline levels: Zone 1 SHL = 38 479; Zone 2/3 SHL = 319 900 oysters. (b) If SCPUE is between the threshold and the limit level, reduce SHL by 40 to 50 % below baseline levels: Zone 1 SHL = 32 982 – 27 485; Zone 2/3 SHL = 274 200 – 228 500 oysters.
		Limit: SCPUE is 15 pearl oysters per hour	If SCPUE is below the limit level, reduce SHL by 50 to 100 % below baseline levels: Zone 1 SHL is < 27 485; Zone 2/3 SHL is < 228 500 oysters.
Level 4 stock assessment incorporating fishery-independent surveys	Annual standardised fishery-independent catch rate (SCPUE) of larger pearl oysters (> 175 mm) in Zone 2/3 of the POF	Target: SCPUE is 15 pearl oysters per hour	Baseline SHL of up to 53 000 larger (>175 mm) oysters for Zone 2/3 to be taken within the SHL for culture pearl oysters
		Threshold: SCPUE is 10 pearl oysters per hour	(a) If SCPUE is between the target and threshold level, reduce SHL of larger oysters (>175 mm) by 30% below baseline level: Zone 2/3 SHL = 37 100 oysters. (b) If SCPUE is between the threshold and the limit level reduce SHL of larger oysters (>175 mm) by 40 to 50 % below baseline level: Zone 2/3 SHL = 31 800 – 26 500 oysters.
		Limit: SCPUE is 5 pearl oysters per hour	If SCPUE is below the limit level reduce SHL of larger oysters (>175 mm) by 50 to 100 % below baseline level: Zone 2/3 SHL < 26 500 oysters.

7.1 Harvest strategy framework

The *Western Australian Silver-Lipped Pearl Oyster (Pinctada maxima) Resource Harvest Strategy 2016-2021* (POF Harvest Strategy) has evolved over the development of the fishery and has recently been formalised as a Fisheries Management Paper (DoF In Press). It makes explicit the management objectives, performance indicators, reference levels and harvest control rules for this resource, which are taken into consideration by the Department when preparing advice for the Minister for Fisheries. The harvest strategy has been developed in line with the Department's over-arching Harvest Strategy Policy (DoF 2015) and relevant national policies / strategies (ESD Steering Committee 1992) and guidelines (e.g. Sloan et al. 2014).

The following sections provide an overview of the harvest strategy in place and should be read in conjunction with the *Western Australian Silver-lipped Pearl Oyster (Pinctada maxima) Resource Harvest Strategy 2016 – 2021* (DoF 2016).

7.1.1 Design

The harvest strategy for *P. maxima* is a constant exploitation approach whereby the same proportion of the stock is harvested each year. Since 1985 this approach has been operationalised through an annual TAC, divided into ITQs, which is set in proportion to overall stock abundance.

The harvesting approach accounts for this species being long-lived, with effort being primarily targeted on the young, fast-growing males that are the optimal size for pearl culture. The bases of this approach are spat settlement surveys, which are used to calculate an index of abundance of 0+ and 1+ oysters, and the standardised commercial catch per unit effort (SCPUE) of culture pearl oysters (120 – 175 mm SL), which is used as an index of abundance. These indices have been used to develop two strongly-predictive relationships: firstly between spat abundance and culture pearl oyster SCPUE four years into the future and secondly, between the current season's sustainable harvest level (SHL) and culture pearl oyster SCPUE. As the catch of culture pearl oysters is comprised mainly of two age classes (4+ and 5+ pearl oysters), these relationships allow recommendations on a SHL to be made up to three years in advance based on the spat settlement surveys. The numbers of larger pearl oysters (> than 175 mm SL) that may be collected is currently co-managed through a voluntary agreement between the Department and licence holders.

The control rules in place ensure that the catch is reduced when predicted recruitment is low, in order to provide increased protection to the stock, but also allows the catch to be raised in years when predicted abundance is high.

The harvest strategy design is built around the annual fishing, assessment, and TAC setting cycle. Fishing usually commences in March/April, and ceases in June/July. In-season monitoring during the fishing using both fishery-dependent and independent data (Table 7.2) is immediately followed by a stock assessment (July to October) and calculation of a SHL for the following year. The outcomes of this process are presented to the SAWG in October,

which in turn provides advice to the CEO who makes a formal TAC determination in November (see Section 16.2.1).

7.1.2 Evaluation

The antiquity of the POF, which has sustained commercial fishing for over 100 years (Figure 2.8), has primarily arisen because of continual evaluation of the harvest strategy. The introduction of pearl culture in 1956 began the process of shifting fishing effort away from the larger sized pearl oysters that were breeding animals (predominately female; Figure 3.3) towards smaller, younger fast-growing males more suitable for pearl culture. This process culminated in the current harvest strategy, which involves setting a SHL (and TAC), based on knowledge of current stock abundance and predictions of future stock abundance up to 4 years ahead. The aim is to achieve the target catch rates through application of a variable TAC but a relatively constant level of effort. This harvest strategy has maintained stocks at levels well above that needed to ensure sustainability.

In recent years the stock has at been at very high levels, aided by an exceptional year of 0+ recruitment in 2005. The assessment process, which involves using information on catch rates and recruitment levels to predict future SHLs, provided the necessary information to increase TACs and allow the pearling industry to make best use of the resource when abundance levels were very high. The same approach resulted in the TAC being reduced in 2012 to limit catches when stock abundance returned to more normal levels. It is therefore concluded that the current harvest strategy has been highly successful in achieving its objectives, i.e. maintain sustainability and maximise economic returns.

7.1.3 Monitoring

There are a range of monitoring programs in place to determine if the harvest strategy is working (Table 7.2, Section 7.4.1). The programs include compulsory daily catch returns, commercial catch sampling and fishery-independent surveys. The outcomes of assessment of data from the monitoring programs are presented to the SAWG in October, which in turn provides advice to the CEO of the Department. The status of the POF and the pearling industry in general is reported each year (e.g. Hart et al. 2014).

There is clear evidence from experience gained in past years that the monitoring in place ensures that actions are taken to maintain stock sustainability. In 2005, the monitoring program detected exceptionally high recruitment of 0+ spat (Figure 7.9). This indicated a much higher SHL was possible and that it was appropriate to increase future TACs to allow the pearling industry to maximise economic use of the available resource. Subsequently, more recently the TAC were adjusted downwards as the information on recruitment indicated this was necessary to provide increased protection of the stock now that the strong year-class had passed through the POF and recruitment had returned to more normal levels. There is every expectation that the monitoring in place will continue to determine whether the harvest strategy is working effectively.

7.1.4 Harvest strategy review

It is recognised that fisheries change over time and that a review period should be built into each harvest strategy to ensure that it remains relevant. The *Western Australian Silver-lipped Pearl Oyster (Pinctada maxima) Resource Harvest Strategy 2016 – 2021* will remain in place for a period of five years, after which time it will be fully reviewed; however, given that this is the first formal harvest strategy for this resource, this document may be subject to further review and amended as appropriate within the five year period.

At an operational level, the harvest strategy is under continual review. The effectiveness of the harvest strategy to maintain breeding stock is internally reviewed annually and reported on in the annual Status Reports of the Fisheries and Aquatic Resources of Western Australia (Hart et al. 2014) as well as at the AMMs attended by Departmental staff, PPA, WAFIC and pearling industry members.

At a strategic level, the Department currently works to an approximate 5-year planning cycle for all Western Australia's fisheries under "FishPlan" (DoF, operations document). This planning cycle outlines research, monitoring, assessment, compliance and management activities across the Department, which are assessed and reviewed to reflect management strategies and risks.

7.2 Reference points

The performance of the POF is assessed annually using target, threshold and limit reference points based on the commercial SCPUE of culture pearl oysters (specifically between 120 – 175 mm) that currently make up the majority of the catch. Preliminary reference points for larger pearl oysters (> 175 mm) are also being developed based on SCPUE from fishery-independent monitoring and have been included in the first formal harvest strategy for the POF (DoF 2016).

7.2.1 Culture pearl oysters (120 to 175 mm SL)

The primary performance indicator for the *P. maxima* resource is the SCPUE of culture pearl oysters (120 to 175 mm), over the reference period from 1979 to 2014. The SCPUE is the mean annual number of culture pearl oysters caught per hour within Zone 2/3 of the POF (Figure 7.1). The SCPUE index is available from 2003 onwards, during which time it has been highly correlated with the unstandardised CPUE ($r^2 = 0.98$). The high correlation between SCPUE and the 0+ spat index from 4 to 5 years previous ($r^2 = 0.96$) confirms that the catch rates are indicative of culture pearl oyster abundance.

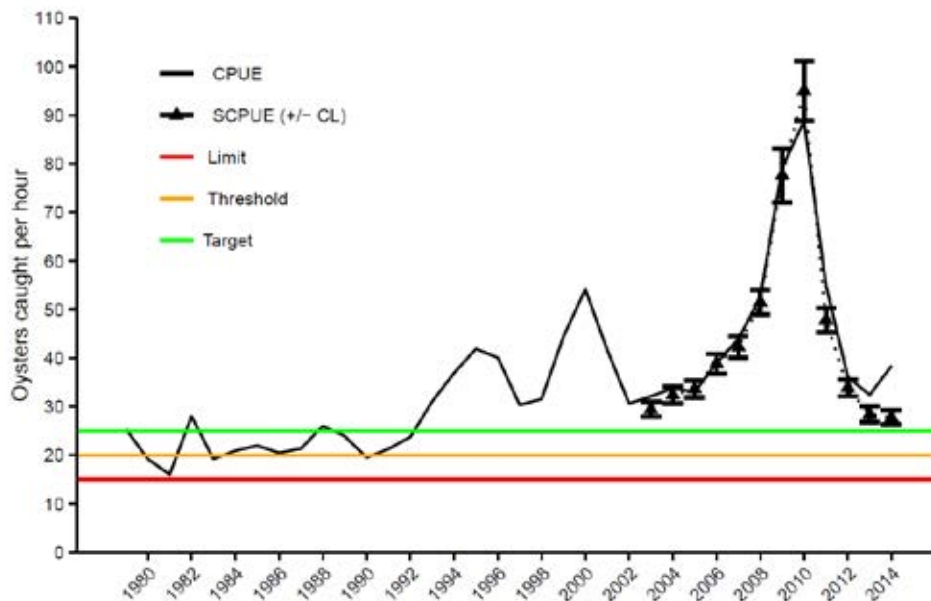


Figure 7.1. SCPUE performance measure, and associated target, threshold and limit levels of culture pearl oysters (120 to 175 mm). Unstandardised CPUE is shown for comparison.

7.2.1.1 Level of limit reference points

The limit reference level for *P. maxima* is an SCPUE of 15 culture pearl oysters per hour (Table 7.1). This level coincides with a recruitment failure as estimated by the current predictive model for SCPUE (16.7 ± 3.3 pearl oysters) when settlement is 0 (see Figure 6.13 and Figure 6.14). This level is also close to the lowest value recorded in 1981 of 16 pearl oysters per hour. The ongoing sustainability of the stock over the last 36 years indicates that this limit reference level is set above the level where there is a substantial risk of recruitment impairment.

7.2.1.2 Level of threshold reference point

The threshold reference level for *P. maxima* is an SCPUE of 20 culture pearl oysters per hour (Table 7.1). This level is 33 % above the limit reference level and is used to provide an early warning that stock abundance is declining, enabling management action to be taken to reduce exploitation before the limit reference level is reached.

7.2.1.3 Level of target reference point

The target reference level for *P. maxima* is an SCPUE of greater than 25 culture pearl oysters per hour (Table 7.1). This level has been set well-above the limit and threshold reference levels, with the intention of maintaining the stock at levels of production consistent with B_{MSY} . Considering that the POF has evolved such that much smaller quantities of pearl oysters are now taken compared to pre-WW2 level, maintaining SCPUE above the target reference point is highly likely to ensure that the pearl oyster stock remains well above a level where fishing would have an impact on recruitment.

7.2.2 Larger pearl oysters (>175 mm SL)

The preliminary performance measure for larger *P. maxima* is the fishery-independent SCPUE of pearl oysters >175 mm SL collected during annual population surveys that have occurred since 2007 in Zone 2/3 of the POF (Figure 7.2, see Sections 6.1.2.4 and 7.4.2.5.2).

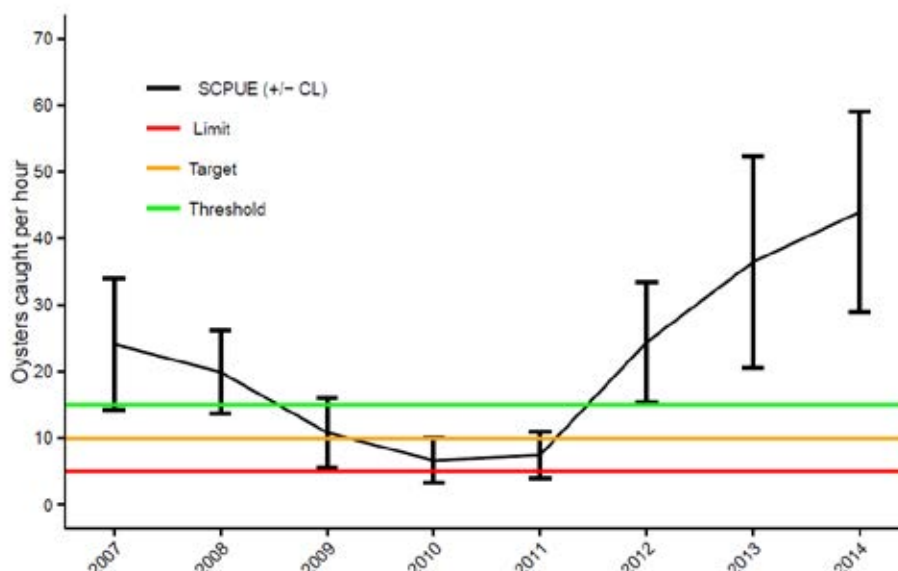


Figure 7.2 Preliminary fishery-independent SCPUE performance measure, and associated target, threshold and limit levels for larger pearl oysters (>175 mm).

7.2.2.1 Level of reference points

Preliminary reference levels have been set based on the reference period from 2007 to 2014. This is when routine monitoring of larger pearl oysters commenced and is a period when the stock is known to have been above the point of recruitment impairment (PRI). Nominal limit, threshold and target reference levels have been set at a SCPUE of 5, 10, and 15 larger pearl oysters per hour in Zone 2/3, respectively. The limit reference point is slightly below the lowest SCPUE of 6.6 pearl oysters per hour observed during the reference period. Reference points will be refined and linked to meaningful biological levels as more information is collected.

7.2.3 Appropriateness of reference points

The SCPUE reference points in place for culture pearl oysters allow for a flexible management response that is based on both the trends in abundance of pearl oysters currently being harvested, and the predicted future abundance. The long-term nature of the raw CPUE index (35 years; Figure 7.1) which is closely correlated with the SCPUE index ($r^2 = 0.97$; Figure 7.1) and the relationship between 0+ spat and SCPUE means that it is an appropriate abundance index to use in the management of the POF. Catch rate is closely monitored and thus can be successfully implemented as a performance measure.

With respect to the predicted future abundance, the 19-year time series of recruitment in this fishery, as measured by the 0+ “piggyback spat” settlement index (Figure 7.9) has been shown to be a good predictor of SCPUE at the appropriate time lags (Figure 6.13). The value

of the predicted SCPUE is that it enables pro-active management of a year-class, allowing at least three years for a management response to be implemented before fishing the year-class.

It is intended that the preliminary reference points currently being developed for larger *P. maxima* will ultimately function in similar way to those for culture pearl oysters.

7.2.4 Low trophic level species target reference point

As filter feeders with robust shell, *P. maxima* is not considered to be a major prey source upon which the overall food chain is highly dependent. Therefore there are no reference points specifically relevant to this as a lower trophic level species.

7.3 Harvest control rules

7.3.1 Design and application

7.3.1.1 Culture pearl oysters (120 to 175 mm SL)

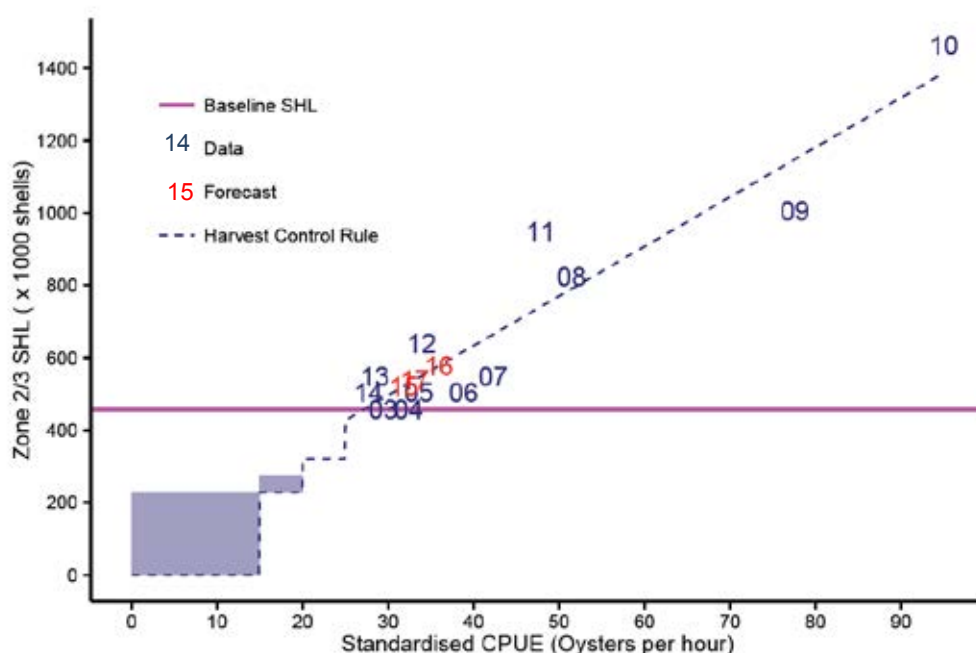


Figure 7.3. Harvest control rule for *P. maxima* in the Zone 2 fishery. The blue numbers are the data (SHL and SCPUE) for each historical year (12 = 2012 etc.), the green numbers are the predicted SHL for future years (15 = 2015; 16 = 2016 etc.)

A summary of the harvest control rules for culture *P. maxima* is provided in Table 7.1, and a graphical representation is shown in Figure 7.3. In line with a constant exploitation harvesting approach, control rules calculate a SHL in Zone 2/3 of the POF each year based on the SCPUE. When the SCPUE is at or above target levels, the harvest control rule is to calculate the Zone 2/3 SHL as a function of stock abundance (SCPUE) using a linear regression model that is updated annually. The equation for calculating the 2015 SHL is as follows:

$$SHL_n = 13.7(SCPUE)_n + 85.3; r^2 = 0.87$$

where SHL_n is the SHL of pearl oysters (120 – 175 mm; $\times 10^3$) in the harvest year n , and $SCPUE_n$ is the abundance of pearl oysters in year n (Figure 7.3). The lag time between settlement and recruitment into the POF is four years; consequently SHL predictions can be made up to four years ahead using the predicted SCPUE (Figure 6.13). Figure 7.3 shows that the SHL is likely to remain similar in 2015, but could be increased in 2016.

When the stock is below target levels, harvest control rules adjust the total SHL against a ‘baseline’ of 457 000 pearl oysters for Zone 2/3 and 54 970 for Zone 1 (Table 7.1, Figure 7.3). These are the lowest values of the SHL since 2003 when the SCPUE index began. A range of fixed and variable reductions to the baseline SHL are made to ensure that exploitation is reduced as the stock abundance decreases and the limit reference level is approached. This precautionary approach is used since the stock has not previously been below the point where recruitment is impaired, and consequently, the relationship between spat abundance and legal-sized abundance at low population sizes is not known.

If SCPUE is forecast to fall below the target level, a reduction in the SHL of 30% below the baseline level is triggered across the POF. SCPUE falling below the threshold triggers a reduction of 40-50% in the baseline SHL, while falling below the limit level triggers a reduction of 50–100% in the baseline SHL.

The harvest control rule, while effective in clarifying the desired level of sustainable harvest, is not the ultimate arbiter. The process of setting the TAC within the POF first requires the presentation of the findings to the SAWG. SAWG recommendations, discussions at the AMM and recommendations from the PPA are then provided to the CEO, as well as advice from fisheries managers, to make a determination on the TAC (see Section 16.2.1).

7.3.1.2 Larger pearl oysters (>175 mm SL)

A detailed account of the decision rules relating to the harvest of larger pearl oysters (>175mm SL) is described in the *Western Australian Silver-lipped Pearl Oyster (Pinctada maxima) Resource Harvest Strategy 2016 – 2021* (DoF 2016). Following dedicated population surveys of this component of the stock between 1999 and 2001, Hart and Friedman (2004) estimated that a SHL of up to 53 000 larger pearl oysters could be taken as part of the overall Zone 2/3 SHL each year. In good recruitment years a greater harvest of larger pearl oysters could be sustained if information on recruitment strength was available.

In recent years, exceptionally strong recruitment from 2005 cohort has resulted in a high abundance of larger pearl oysters, and population surveys have indicated an SHL of between 190 000 and 300 000 pearl oysters could be harvested in addition to (as opposed to within) the culture SHL (see Section 6.1.2.5). In the future, as the stock returns to normal levels of abundance, it is intended that the previous SHL of 53 000 larger pearl oysters will apply. In coming years it is also envisioned that an SCPUE-based harvest control rule will be implemented for larger pearl oysters (as occurs currently for culture pearl oysters), consistent with a constant exploitation harvesting approach (Table 7.1).

When the stock is above target levels, harvest control rules will recommend a SHL that is proportional to stock abundance. Below target levels, harvest control rules will adjust the SHL against the previous ‘baseline’ level of 53 000 pearl oysters (Hart and Friedman 2004). Reductions in the baseline SHL of 30%, 40-50% and 50-100% will be triggered if the SCPUE falls below the target, threshold and limit levels, respectively.

7.3.2 Accounting for uncertainties

There is a lack of knowledge of the stock-recruitment relationship (SRR) for *Pinctada maxima* and therefore the level of breeding stock below which there would be an unacceptable risk of recruitment failure is unknown. However recruitment variation has been explained by environmental factors (see Sections 3.1.3.4 and 7.4.2.5.4). The lack of a SRR in part reflects the fact that the POF has never been at the point where recruitment failure has occurred, noting that the POF has been operating for over 100 years with greater levels of catch in the early years, particularly prior to the Second World War (Figure 2.1). Having said this, the POF is currently focused on a smaller area and a different size class than in the past so the current harvest strategy is designed around protecting the current fishing grounds and ensuring that there is sufficient abundance of culture-size pearl oysters that are the focus of the POF. In consideration of this uncertainty, the control rules and associated reference points are designed to be precautionary and take into account knowledge of annual trends in spat settlement, which have been closely related to future legal-size stock abundance (Figure 6.13).

In addition to control rules associated with the harvesting of wild pearl oysters, additional control rules are in place to protect the stock against a wide range of other uncertainties.

7.3.3 Evaluation

The harvest control rule and associated reference points are continually evaluated and refined. Each year the control rule is recalculated using the latest estimate of stock abundance (SCPUE) and pearl oyster spat settlement to ensure that all historical changes in abundance and fishing patterns can be accounted for. The changes in fishing efficiency through the experience of divers and environmental factors affecting fishing efficiency are also taken into account. The control rule is then applied against existing reference points to see whether they are still relevant, and if not, updated reference point are estimated. The updated control rule is documented each year, and presented to the SAWG for consideration and feedback. When the harvest control rule is unanimously accepted it is used to provide annual estimates of proposed harvest. The testing and evaluation cycle is repeated every year and reported on annually (see Hart et al. 2014).

7.4 Information and monitoring

7.4.1 Range of information

A comprehensive range of data has been collected on *P. maxima* throughout the POF, with catch records dating back to the late 1800s. Compulsory daily catch and effort logbooks were introduced in 1979 (see Appendix E and Appendix F), and additional observer monitoring, research surveys and pre-recruitment monitoring have been implemented since then (Table 7.2).

Table 7.2. Summary of current research and monitoring activities for the Pearl Oyster Fishery. CDR – Catch Disposal Records (i.e. formal quota reporting).

Data type	Fishery dependent or independent	Analyses used in stock assessment	Additional analysis and purpose	Areas of data collection	Frequency of data collection	History of data collection
Catch and effort returns	Dependent	Legal Catch Rate	Check on TAC	Whole Fishery	By individual drift dive	Daily CDR logbook since 1979
Commercial length-monitoring surveys	Dependent	Catch rate of different length classes	Size composition of catch	Spatial and depth stratified	Research sampling design by area	Since 1999
Population surveys	Independent	Densities and catch rates of all age classes (Age 2+)	Recruitment predictions and breeding stock size	Spatial and depth stratified	Research sampling design by area	Every 5 – 10 years since 1988. Annually since 2007
Recruitment monitoring	Independent	Age 0+ and Age 1+ spat settlement index	Future stock predictions in harvest strategy	Spatial and depth stratified	Research sampling design by area	Annually since 2001
Environmental monitoring (catch distribution by habitat type; SST, rainfall, and wind data)	Dependent and Independent	Environmental influences on abundance and fishing efficiency	Changes in the environment that may impact on catch rate or biology	Fishery and bioregion scale	Annually	On board vessels since 2000; Government datasets since 1979.
Targeted research projects	Dependent and Independent	SHL of larger pearl oysters	Life history characteristics	Whole fishery	One off	1999 to 2001

7.4.2 Monitoring

7.4.2.1 Commercial catches

There is a statutory obligation for pearl oyster fishers to provide a daily catch and effort record with catch and effort recorded for 10 x 10 miles statistical reporting blocks. This has been in place since 1979, however, historically there is a long-time series of catch records from the POF (since 1890; see Section 1). Information recorded in the daily catch and effort form includes catch by numbers of the two size classes ('culture' and 'MOP'), effort in dive hours, depth fished, statistical reporting block, visibility, quota record, and tag numbers for the panels where pearl oysters are stored (Appendix E). The tag numbers are a compliance tracking method as part of the overall quota monitoring strategy. An example of the statistical reporting grid is found in Appendix F.

7.4.2.2 Commercial effort

The POF generally operates for three to four months per year, usually between March and July. Start and end dates varying dependent on current quota and environmental conditions, for example, the presence of cyclones often delays fishing trips. During this period there are between 5 and 10 discrete fishing events (trips) per year, which are scheduled around the neap phase of the tidal cycle (~ 2 trips per month).

Commercial effort (hours of fishing) is recorded simultaneously with the catch (see Section 7.4.2.1) and therefore has the same checks and balances as the catch information. As a result of the constraints of diving to avoid decompression illness, the estimates of effort derived from the daily logbook are highly accurate as they are dependent on pre-determined depth/time profiles which are consistent between pearl divers and from year to year. These profiles are tightly regulated through health and safety regulations, which include a database that is checked by health and safety officers for compliance with approved dive standards. In summary, we have a very high level of confidence that the effort data are accurate.

7.4.2.3 Catch rates

Catch rates are derived from the daily catch and effort logbook, which has complete coverage of the entire POF. The data collected are of the finest possible resolution, i.e. full details are recorded for every single dive. The indices derived from these data are standardised to account for the variables that influence the catching efficiency and abundance (see Section 6.1.1), and used as one of the performance measures in the harvest strategy. The indices are always presented with details of the associated levels of uncertainty (confidence intervals; Figure 7.1) and thus there is good understanding of the inherent uncertainties in the catch rate based indices. Hart et al. (2011) carried out a detailed analysis of the main environmental variables influencing abundance and fishing efficiency in the POF, which has been used to inform and improve the standardised catch rate abundance index.

The long-term trend in the raw catch rate (oysters caught per dive hour) in the Zone 2/3 of the POF shows an increasing trend, punctuated by clear peaks in CPUE indicating increased abundance of pearl oysters for those years (Figure 7.4). The standardised CPUE index (Figure 7.1), available for 2003 onwards and the basis for the performance measure, has been highly correlated with CPUE ($r = 0.98$) for the years 2003 to 2012. This indicates that the historical catch rates were indicative of trends in pearl oyster abundance. The relationship between the standardised CPUE and the 0+ spat 4-5 years previously also confirms that the catch rates are indicative of legal-shell abundance.

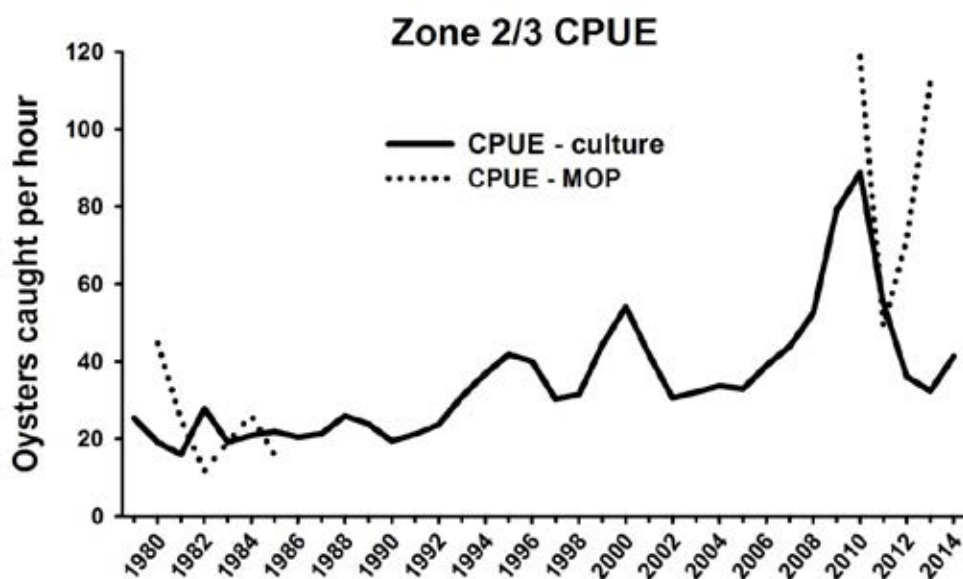


Figure 7.4. Raw CPUE of ‘culture’ (120 – 175 mm SL) and larger (≥ 175 mm SL; MOP) sized animals in the Zone 2/3 *P. maxima* fishery.

7.4.2.4 Recreational, charter and customary catch

There is no recreational or charter component to the fishery and customary catch is considered negligible.

7.4.2.5 Other monitoring

7.4.2.5.1 Length frequency monitoring

Research observers on board commercial vessels undertake a length frequency monitoring programme annually. The observers undertake measurements of pearl oysters during a minimum of 30 % (~ 3 trips) of the 5 to 10 discrete fishing trips that occur in the POF each year. Data are collected according to a sampling programme targeting two “drifts” per day (drift 2 and 5). A ‘drift’ is the basic unit of fishing within the POF, whereby the pearl divers are deployed over a 30 – 60 minute period, depending on depth, harvesting all legal-size pearl oysters encountered.

Data collected are length frequency data, spatial location, and incidence of bioeroding sponge infestation, which is a general measure of the health of the pearl oyster. An example of the data collection sheet is found in Appendix G. Between 4000 and 13 000 pearl oysters are measured from 100 – 200 sites per year. An example of the size-frequency of the catch obtained from different statistical areas is shown in Figure 7.5. This sampling is of a good level and representative of the POF. The research observers are highly experienced and have all the equipment required to record accurate data. There is a high level of cooperation with the pearling industry in this regard which is conducive to effective sampling.

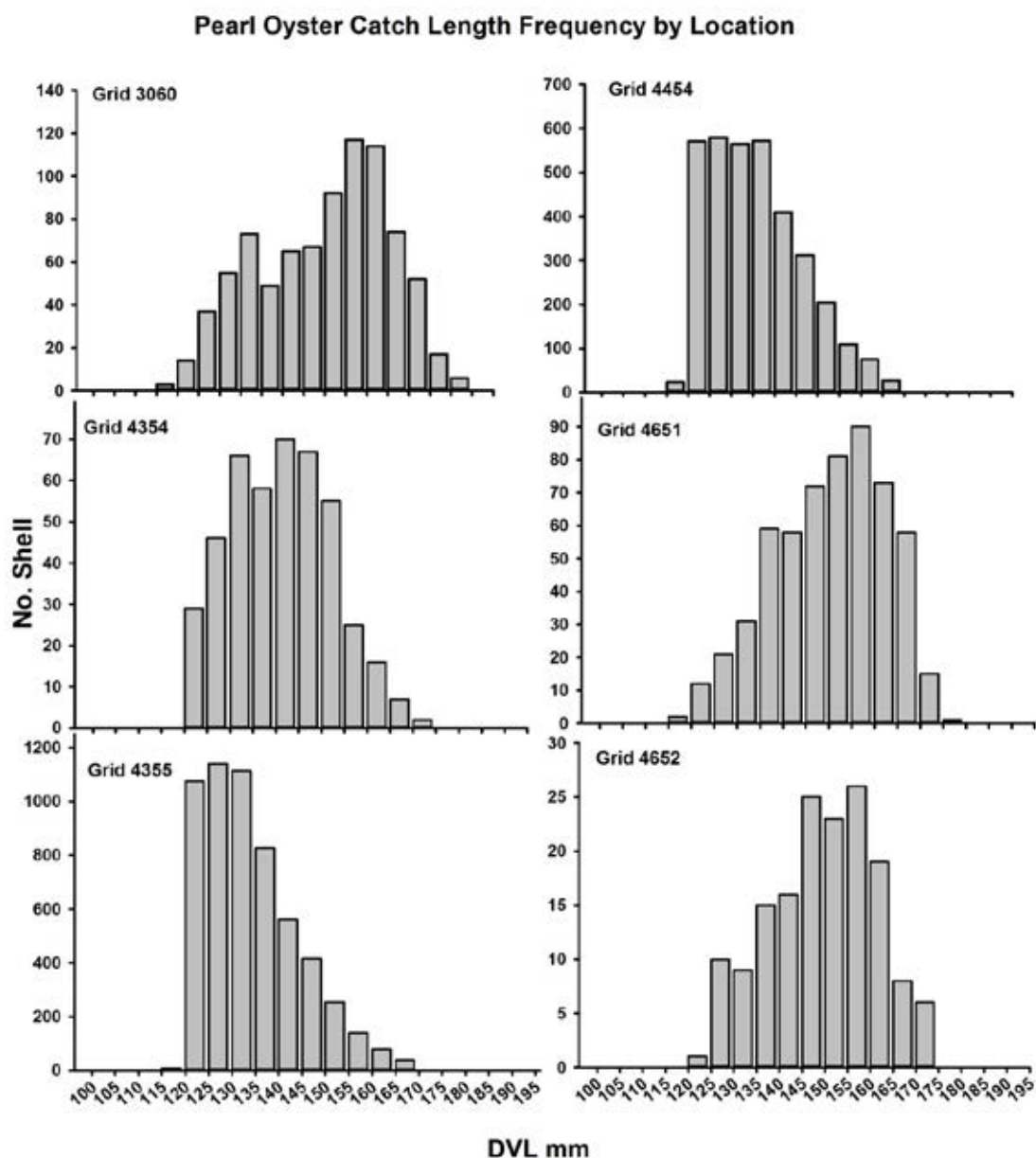


Figure 7.5. Length-frequency composition of *Pinctada maxima* by statistical grid during commercial monitoring in 2003.

7.4.2.5.2 Population surveys

Fishery-independent population surveys to estimate total stock abundance have been carried out periodically over the history of the POF. The first structured survey of the Zone 2/3 stocks was in 1988 (Penn and Dybdhal 1988), followed by another in 2001 (Hart and Friedman 2004). These surveys provide an independent time series of abundance to compare against catch rates. Hart and Friedman (2004) also provided total population estimates and sustainable harvest regimes for larger pearl oysters (>175mm SL).

In 2007, population surveys were incorporated into the annual monitoring program for the POF (Figure 7.6). Research personnel design the sampling regime at specified fixed sites each year and also several random sites within the POF. The Department hires highly experienced commercial divers to sample the target areas, capturing all observed oysters.

Research personnel undertake the recording of all measurements. Again, there is a high level of confidence that the data collected during these surveys are highly accurate.

Population length-frequency data are collected by spatial location (GPS points), and depth. Between 3000 and 5000 pearl oysters are measured from 30 – 150 sites per year. An example of the size-frequency of the population in 2007 and 2008 obtained from this sampling is shown in Figure 7.6. These surveys provide both an index of pre-recruitment abundance (“Chicken”) that can be compared with earlier predictions from the recruitment spat surveys (see Section 7.4.2.5.3 below), and an index of breeding stock abundance (pearl oysters >175mm SL: “MOP”) which can be compared over time. Again, there is a high level of confidence that the data collected during these surveys are highly accurate.

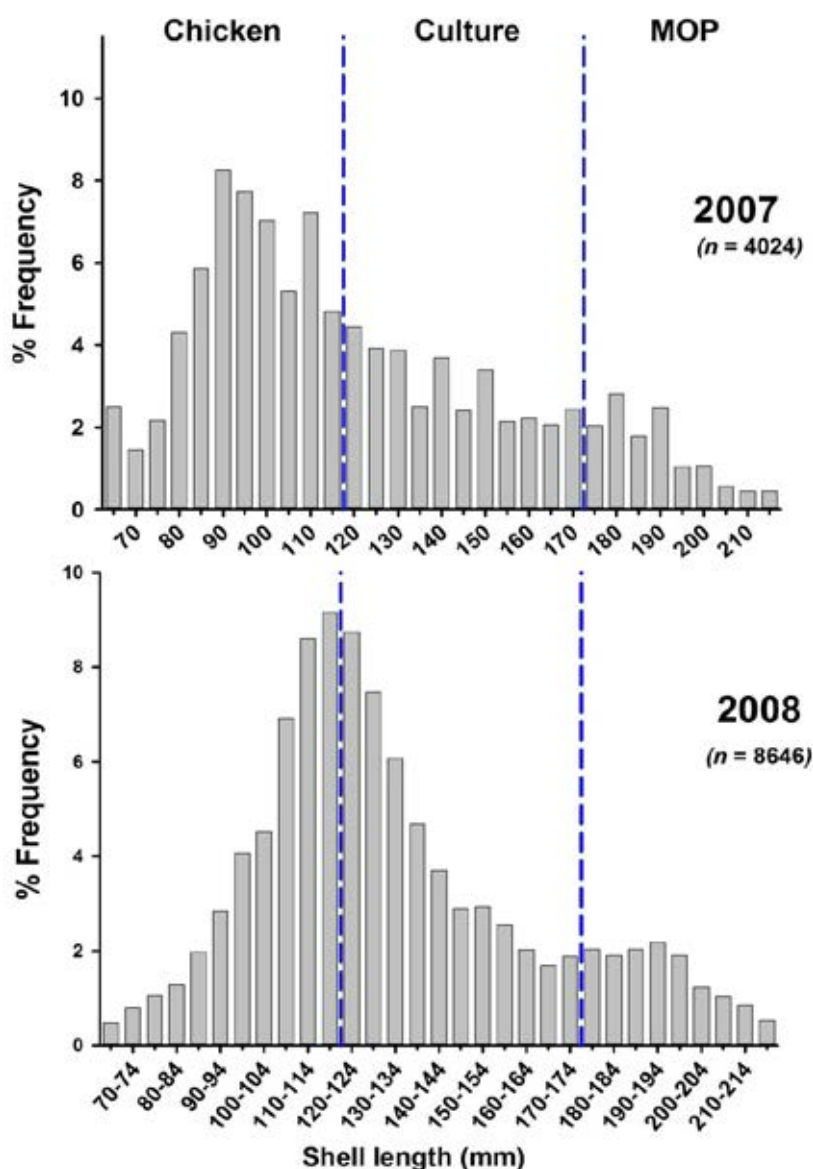


Figure 7.6. Length-frequency composition of *Pinctada maxima* from population surveys in 2007 and 2008. A large recruitment pulse beginning to enter the fishery in 2008 is observed as a result of the good 0+ settlement in 2005. The lower and upper commercially fished lengths are the dashed blue lines. “Chicken” are undersize oysters, ‘Culture’ are the targeted oysters, “MOP” are the broodstock.

7.4.2.5.3 Recruitment monitoring

P. maxima primarily spawn in October/November, and the larvae spend 3 – 4 weeks in the water column (Rose et al. 1990) before settling onto appropriate habitat, that includes adult pearl oyster shells, primarily during November and December. A unique settlement index (the “piggyback” spat recruitment index) that measures the abundance of each year class (Figure 7.7) was developed by Hart and Joll (2006). The piggyback spat index is derived from examining the occurrence of spat (juvenile pearl oysters) which settle onto adult pearl oysters as part of the commercial monitoring program. The annual change in recruitment strength measured by this index is one of the primary tools used to forecast future stock abundance and consequently, catch quotas (see Figure 6.13). Between 30 000 and 155 000 adult pearl oysters are inspected each year (Table 7.3).

The “piggyback” spat index involves counting spat that have recently settled on adult pearl oyster shells. A random sample of 100 – 300 adult pearl oysters caught by commercial divers during a drift dive is inspected for these “piggyback” spat and abundance and recorded as spat per 1000 pearl oysters (referred to as shell). The sampling program is structured around the daily drift-diving profile, with spat settlement and habitat data (see Appendix H) collected on 4 to 6 drifts per day. Spat samples are obtained from 200 – 800 drift dives per fishing year, counted, measured, and separated into two age classes based on their size frequency (Figure 7.8). The age classes are newly settled spat (age 0+) between 5 and 35 mm SL (4 – 7 months old), and age 1+ between 35 and 75 mm SL (16 – 19 months old). The age classes were determined from cohort frequency analysis (Hart and Joll, 2006). Recruitment data is collected simultaneously with habitat data as part of the on-vessel component of the environmental monitoring program. The current data recording sheet for recruitment and habitat monitoring is in Appendix H.

Uncertainties with this index revolve around the extent to which certain factors influence the settlement rates of recorded spat and whether the index is representative of the actual settlement rates experienced by the population. For example, fishing areas and depth all significantly influence settlement rates and are accounted for by using a statistical procedure (see Section 6.1.1). However, the results of regression analyses comparing commercial catch rates of pearl oysters with previous year’s recruitment show that the factors mentioned account for almost all the variation (see Section 6.1.1). In other words, the uncertainties regarding the robustness of the recruitment index are very well understood and accounted for.

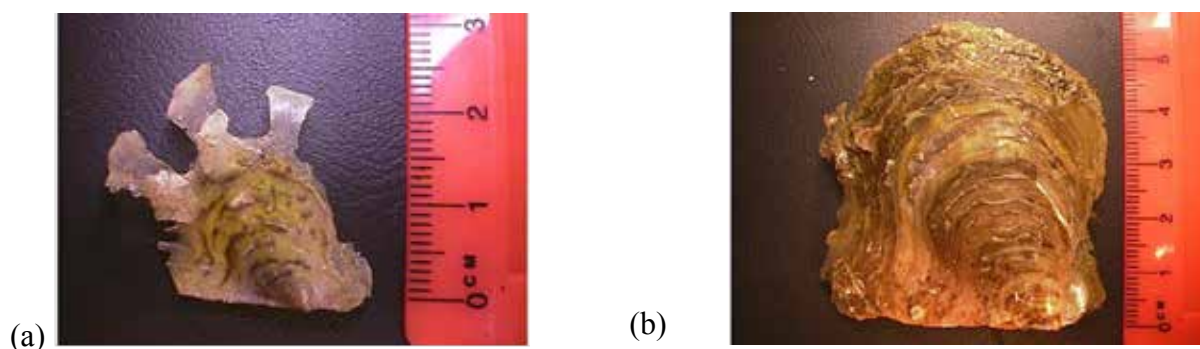


Figure 7.7. *Pinctada maxima* spat found on commercially fished adult shell. A) Age 0+ spat, 17mm DVM, approximately 4 months old; B) Age 1+ spat, 57 mm DVM, approximately 16-18 months old.

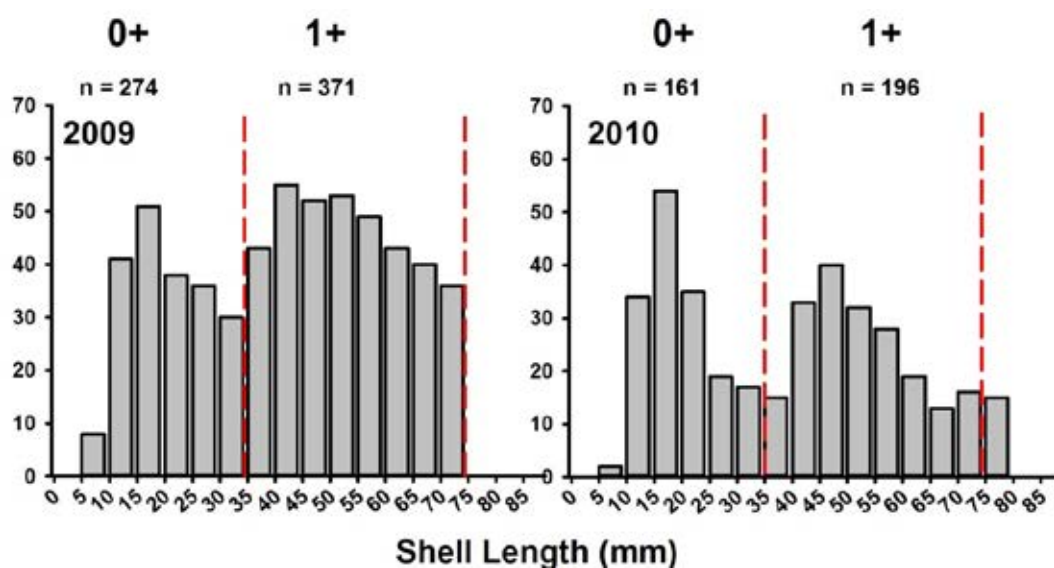


Figure 7.8. An example of size frequency of *Pinctada maxima* spat collected during recruitment surveys in 2009 and 2010. Age classes (0+; 1+) delineated by red dashed lines.

Table 7.3. Recruitment ('piggyback spat') monitoring of *Pinctada maxima* in Western Australia, showing the number (*n*) and per cent (%) of adult oysters caught commercially that were examined for the presence of spat.

Year	Adult shells examined for Age 0+ and 1+ spat	
	<i>n</i>	% coverage
1991	17,900	5
1992	36,000	8
1993	44,000	10
1994	87,000	19
1995	105,000	22
2001	138,000	27
2002	133,000	28
2003	119,000	26
2004	110,000	27
2005	95,000	21
2006	81,000	21
2007	63,000	12
2008	155,000	19
2009	45,000	17
2010	29,000	8
2011	64,000	8
2012	53,000	10
2013	42,900	11
2014	37,500	12

Recruitment year class strength has varied significantly in the 19 years of surveys of the 0+ spat index (Figure 7.9); however, there is no upward or downward trend indicating that recruitment is stable. In general it oscillates between three and seven (spat per 1000 adult oysters), with an average of 4.6 (excluding 2005). However, in 2005, an exceptionally high recruitment occurred (32 spat per 1000 shell), which was seven times the average settlement (Figure 7.9). This year class was tracked by the commercial length frequency and population monitoring programmes as it grew into the POF during 2008 to 2011 (see Figure 7.1). A detailed investigation of various factors to explain this extraordinary settlement year was carried out by Hart et al. (2011) which showed that the settlement was a combination of unusual environmental conditions that occurred during the spawning cycle for that year.

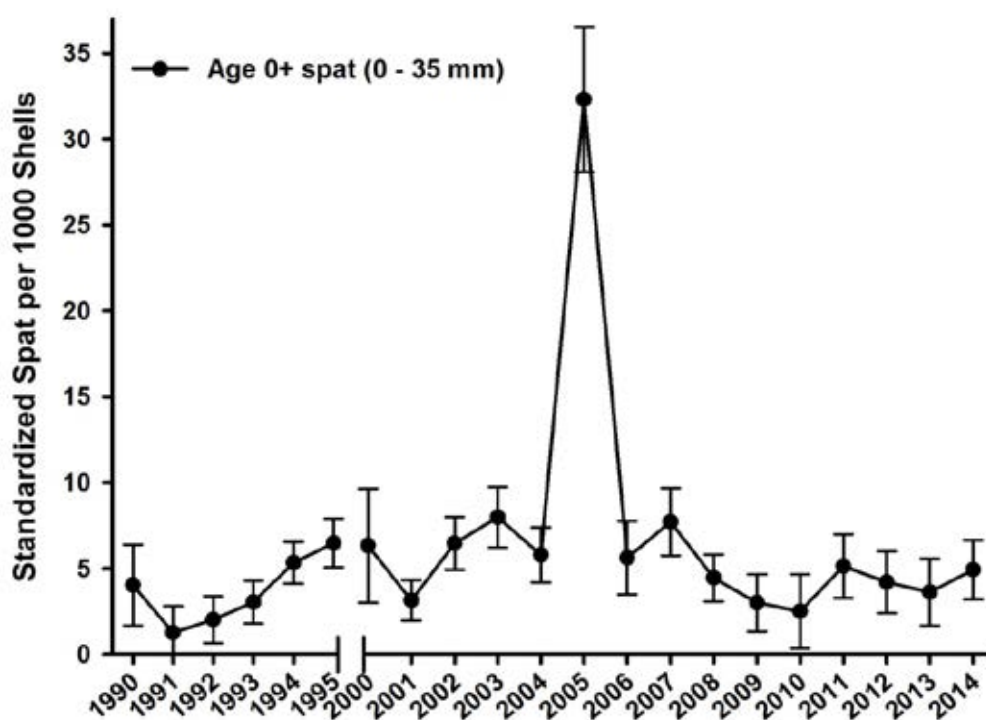


Figure 7.9. Standardised 0+ spat abundance (per 1000 adult shells; \pm CL) in the Zone 2 Pearl Oyster Fishery.

7.4.2.5.4 Environmental monitoring

The environmental monitoring program for the POF consists of two components: (a) on-board vessel monitoring for the three principal environmental factors of depth, water visibility, and habitat type (see Section 12) and (b) long-term monitoring of variables obtained from independent environmental monitoring programs implemented by various Government and NGO agencies. The main variables investigated for their influence on the pearl oyster stocks are SST, rainfall, frequency of cyclones, wind components, and Southern Oscillation Index (SOI).

The two main habitats fished by the POF are ‘garden’ habitat (diverse assemblage dominated by hydroids on sandy bottom; see Section 12) and ‘potato’ habitat (low diversity assemblage on sandy bottoms dominated by ascidians; see Section 12). The relative proportion of these and other types of habitat fished for pearl oysters are monitored each year to assess changes

in distribution of fishing or habitat (Figure 7.10). This monitoring is providing information on which are the most important natural habitats that influence recruitment in pearl oysters; for example recent investigations indicate that settlement is higher in ‘garden’ habitat type.

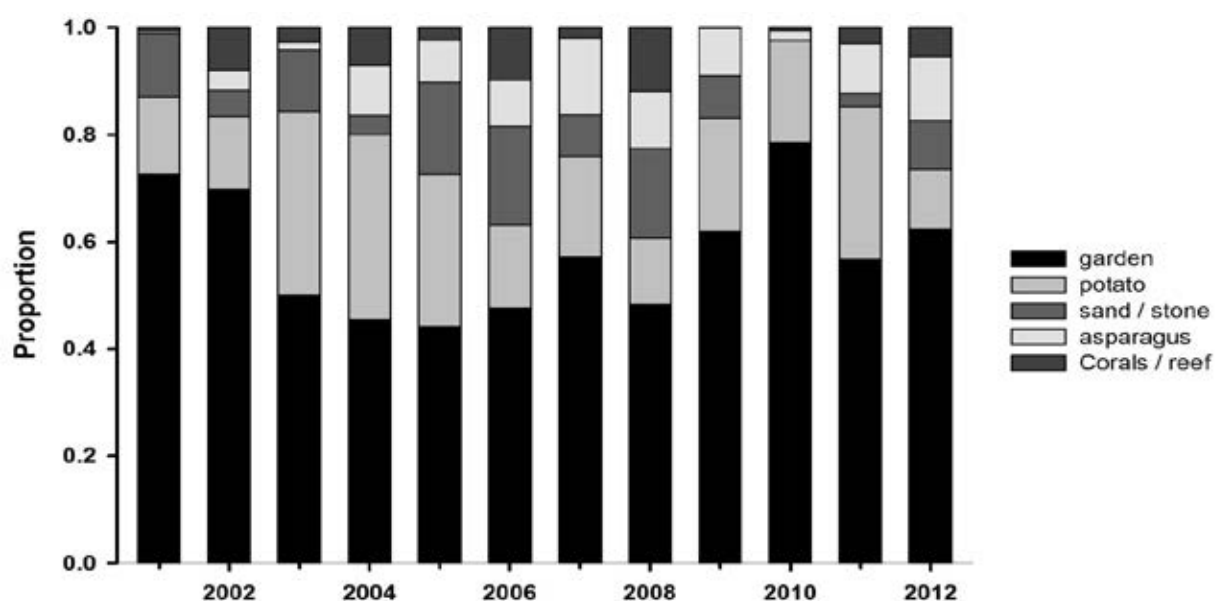


Figure 7.10. Proportion of different habitats fished over time by the Pearl Oyster Fishery. Habitat categories (garden, potato, etc.) are described in more detail in Section 12.

Environmental factors have a relatively large influence on both pearl oyster abundance and fishing efficiency. For example, Hart et al. (2011) detected a significant negative relationship between abundance and rainfall, and positive relationship between abundance and temperature for both spat settlement and CPUE at appropriate lags. Also, northerly winds (negative northings) during December to February significantly enhanced settlement. However easterly winds (negative eastings) in the main fishing month of May positively influenced fishing power (Hart et al. 2011). Consequently, analysis of environmental effects is routinely carried out during stock assessments.

For example, a comparison of current fishery abundance (catch rates) with the annual Southern Oscillation Index (SOI) shows that between 1990 and 1998 the SOI was predominately negative (Figure 7.11). However, the POF has been in a neutral or positive SOI phase since 2006. Whether this has had a direct effect on the low abundance in 2013 and 2014 is an arguable point, except it is worth noting that the last exceptional year of settlement in the Zone 2 of the POF (2005; Figure 7.9) was in a year with a strong negative SOI, indicative of strong El Niño conditions (Figure 7.11).

Long-term trends of other relevant environmental indices such as wind, rainfall, and temperature are shown in Figure 7.12.

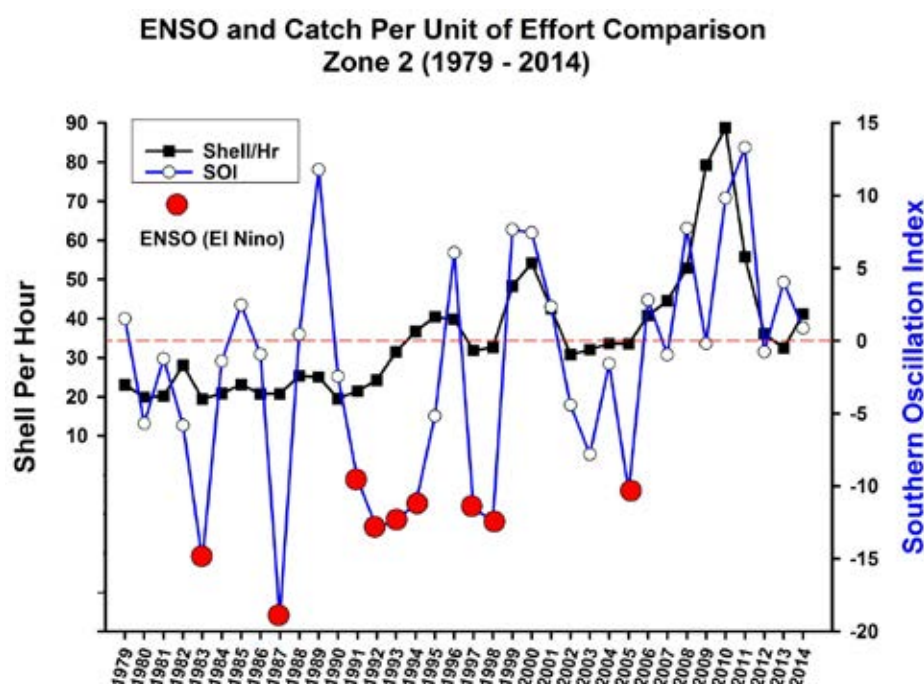


Figure 7.11. Catch rates of *Pinctada maxima* in the Zone 2 fishery compared with the Southern Oscillation Index (SOI) for the period 1979 to 2014.

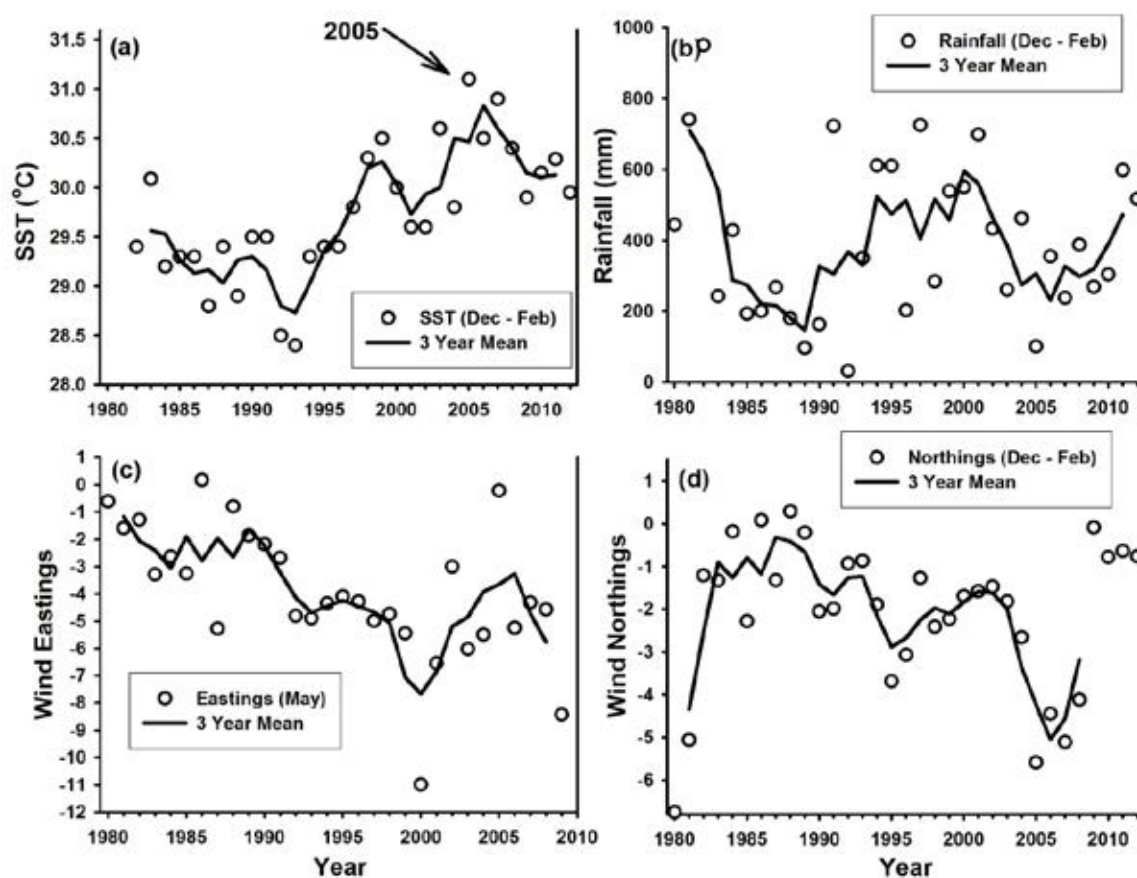


Figure 7.12. Environmental variables during December to February in the Pearl Oyster Fishery from 1980 to 2010.

7.4.2.6 Targeted research projects

In addition to routine monitoring, externally funded, targeted research projects have been occasionally undertaken to address specific knowledge gaps, most notably an FRDC funded project by Hart and Friedman (2004) that investigated the SHL of larger pearl oysters (see Section 6.1.2).

7.4.3 Comprehensiveness of information and uncertainties

P. maxima is currently only targeted by the POF, a commercial fishery that comprises of a relatively small fleet. All catches of the POF are reported and the quota is monitored to the level of individual pearl oysters caught. In addition to over thirty years of accurate quota monitoring, the POF has a long history of records of catch and effort dating back to 1890.

As demonstrated above, there is a large amount of high quality information available for monitoring the status of pearl oyster stocks including multiple indices that contribute to understanding of stock status.

8. Genetic Management

There is a strategy in place for managing pearl cultivation to ensure it has a negligible risk of serious or irreversible harm to the genetic diversity of the wild population. The strategy effectively relates to hatchery-bred *P. maxima*, although this has flow on effects for the cultivation of wild-caught *P. maxima*.

The main component of the strategy is spatial separation of most of the grow-out farms that are located in a different management zone (Zone 3 and 4, Figure 2.3) from the main areas fished by the POF (Zone 2, Figure 2.3).

Other important aspects of the strategy include:

- a limit on the number of hatchery produced oysters that can be seeded (enforced by quota rules and compliance monitoring);
- all broodstock are derived from WA wildstock pearl oysters; and
- There is legislation on the transport of pearl oysters into WA.

The pearling industry is highly regulated by the Department. Access to the POF is limited to holders of the relevant pearling (wildstock) licence, and attached quota (please note that temporary transfers of quota can occur within the POF). Similarly companies producing hatchery-reared pearl oysters must also hold the appropriate hatchery licences, hatchery (seeding) licence if seeding is occurring, health certification and transport approvals when appropriate and pearl oyster farm leases (farm leases). Applications for farm lease are reviewed and approval by the Department. The total farm lease area a company holds is linked to the pearl oyster quota and stock holding held by that company.

The legislation regulating hatchery activities and production includes:

- *Pearling (General) Regulations 1991* controls the records that must be produced in terms of broodstock (e.g. amount received and source location) as well as managing the source of the broodstock (Regulation 44E).
- Broodstock must be produced in that hatchery or taken from Zone 1, 2 or 3 of the Western Australian pearl oyster fishery.
- Part 7C, D & E of the Regulations provides requirements around quarantine and nursery sites (designated areas of a lease where the grow-out of hatchery produced spat is permitted). There are requirements to submit quarterly Nursery Site Stock reports to the Department.
- All transports of pearl oysters¹ into and out of a hatchery require prior approval from a pearling inspector (refer to Regulation 42). Transports of spat out of a hatchery must have a valid health certificate before they are approved.

¹ Note that this currently does not apply to broodstock.

- Additionally, Part 13A of the FRMR also reiterates this requirement of a certificate of health being in force and transported in accordance with approval to transport (Regulation 144G) when transporting is occurring out of a hatchery. Part 13A also sets out spat testing and quarantine site requirements;
- *Ministerial Policy Guideline No 17*, issued pursuant to Section 24 of the *Pearling Act 1990*, requires that pearling licensees clearly identify the specific area within a Lease where hatchery-cultured pearl oysters were prior to seeding.
- The *Pearl Oyster Translocation Protocol* (July 2009, Appendix A) reinforces what needs to occur with the *Pearling (General) Regulations 1991* (Regulation 42) in terms of the movement of pearl oyster spat from a hatchery to a nursery site on a lease. This includes notification of the movement (form to be filled in and submitted to the Broome office), a health certificate to be provided and a transport log sheet to be completed following completion of the transport. .

Given the large connectivity and panmitic genetic population structure of *P. maxima* within WA, it is unlikely genetic testing to measure the success of the management strategy would be possible or effective. Consequently, this has not been incorporated into the current strategy.

The current strategy has been designed to minimise risks to the genetic population structure in the event that hatchery-produced *P. maxima* successfully reproduce. All available information (Johnson & Joll, 1993; Arnaud et al., 2003; Benzie & Smith-Keune, 2006; Southgate and Lucas, 2008) indicates that the current management strategy has been effective.

9. Genetic Information

Periodic studies have been undertaken on the genetics of *P. maxima* in WA, and these form the basis of the management strategy. A synthesis of this information is provided in Section 3.1.2 and can also be found in Southgate & Lucas (2008).

Johnson and Joll (1993) undertook the first study on the genetic structure in northern Australia using samples between Exmouth Gulf and Thursday Island, spanning a distance of 3400 km. Their results indicated that there was substantial genetic subdivision in *P. maxima* populations across northern Australia as a whole, but that the WA population was highly connected over distances of at least 800 km. They also concluded that the transport of 80 to 100 000 pearl oysters from WA to the NT since the early 1980s had not resulted in a significant impact on the genetic structure of *P. maxima* since genetic subdivision was still detectable between the two regions.

Benzie and Smith (2002) further investigated the genetics of *P. maxima* in an FRDC project. The objectives of this project were: 1) To develop assays for regions of highly variable DNA (microsatellites) and mtDNA markers for rapid assessment of genetic variation in pearl oysters; 2) To survey up to eight populations of *P. maxima* throughout the WA coast, including different juvenile age classes, using up to ten highly variable markers; 3) To infer the level of dispersal between populations and the effective population size contributing to the next generation from the genetic data and identify the management implications of these data; and 4) To develop the basic technology for assessment of genetic variation in spat and for future use in improving cultured *P. maxima* stocks. Outcomes of this research included several peer reviewed publications; Benzie *et al* (2003), Smith *et al* (2003) and Benzie and Smith-Keune (2006). The research confirmed that *P. maxima* populations were genetically divergent over large spatial scales, but that within WA waters they could be considered a single genetic stock, with the possible exception of Exmouth Gulf.

Additional studies on the genetics of *P. maxima* in Australia have included a PhD thesis by Lind (2009) and subsequent publications including Lind *et al* (2007), and Lind *et al* (2012).

The genetic management strategy is considered to be highly risk averse in light of the high level of connectivity of *P. maxima* within WA waters and the numbers of hatchery reared pearl oysters compared to the wild stock. For this reason routine monitoring of genetics does not form part of the information collected to support the management strategy.

MSC Principle 2

10. Primary and Secondary Species

10.1 Pearling industry impacts

Under the PA, pearl oyster fishers are only allowed to collect the silver-lipped pearl oyster *P. maxima*. Divers are able to specifically target pearl oysters of choice (species, size and quality), and no other species are collected. Although not directly targeted, commensal biofouling organisms that encrust the pearl oyster shells are collected; however, the harvested pearl oysters are generally young and have relatively little epiphytic growth and low infestation rates (Daume et al. 2009). Previous risk assessments have considered the impact of pearl oyster collection on fouling species populations to be a negligible risk to these species' populations (see Section 10.1.2 below).

During the pearl production process, pearl oysters are seeded with pearl nuclei, which are spheres of shell material taken from other species of bivalve molluscs. As part of the cultivation process, a nucleus is placed in the adductor muscle of the pearl oyster and removed after a period of time when a layer of nacre has been laid down over the nucleus.

10.1.1 Biofouling organisms

After the pearl oysters have been collected, fouling organisms are cleaned off the shell surface by a combination of mechanical scraping with a knife, followed by washing with high pressure seawater (no chemicals are used in the procedure). The material removed is discharged back into the ocean. As the boat is constantly moving during the cleaning, the material is dispersed over a wide area and is rapidly dissipated in the open ocean.

Within WA, primary pearl oyster fouling organisms include coralline algae and sponges, as well as ascidians, fire coral and other algae. Predatory sponges, boring annelids, gastropods and algae can also infest pearl oysters. Following an industry workshop in 2003 that identified bioeroding sponges (*Cliona* sp.) as the primary concern for the future sustainability of the natural pearl oyster resource, the composition of bioeroding sponges (*Cliona* sp.) in wild pearl oyster stocks in WA was investigated by Daume et al. (2009; as part of FRDC-funded project no. 2005/074). *Cliona* sponges burrow into shell causing damage and occasionally death, rendering the half-shell, and occasionally the pearl, unsaleable. While, primary studies identified some aspects of the primary species' life cycle in relation to pest control (Fromont et al. 2005), this project was aimed at providing an understanding of the process of recruitment and transmission of sponges in pearl oysters and an assessment of the source of bioeroding sponges in the environment.

Twenty sites were sampled at 80 Mile Beach to determine the infestation rates of bioeroding sponges in all biotic and abiotic calcareous substrates (covering 800 m² of habitat). Additionally, 1033 pearl oysters were sampled from seven major pearl oyster fishing grounds between 2004 and 2006 for laboratory and histological examination for species identification, along with ~ 67 000 pearl oysters that were visually assessed on-board pearling industry

vessels and the presence or absence of bioeroding sponges recorded. In 2007 and 2008, 180 pearl oyster shells (ranging from 80 – 270 mm shell length) were sampled from three major pearl oyster fishing grounds in order to estimate the area and volume of bioeroding sponge erosions. Smaller pearl oyster shells (< 80 mm SL) were not sampled since previous a study determined that smaller shells have negligible infestation rates (< 1 %; see below). Pearl oyster stock density was determined for each fishing ground using an equation derived by Hart and Friedman (2004), and the density of infested shells was determined by multiplying the estimated pearl oyster stock density with the estimated infestation rate for the targeted (i.e. 4 – 5) age class (Daume et al. 2009).

Three species of bioeroding sponges were identified in the habitat samples, *Pione velans*, *Cliona dissimilis* and *C. orientalis*. Four species identified from the shell samples collected during 2004 – 2006: *P. velans*, *C. dissimilis*, *C. orientalis* and an unidentified species of *Cliona*. In 2007, these same four species were found in fishing grounds off 80 Mile Beach, while seven species were found from the Lacepedes fishing ground (*P. velans*, *C. dissimilis*, *C. orientalis*, two unidentified species of *Cliona* and unidentified species of *Aka* and *Zyzzya*). *P. velans* was the dominant species at all locations and sample periods (Daume et al. 2009).

In pearl oyster shell samples from 2004 – 2006, an estimated 12 % of all shells were affected by bioeroding sponges; however, this may be an underestimate due to the sampling methods used. In comparison, pearl oyster shell samples from 2007 – 2008 had a much higher estimated infestation rate (53 %; excluding < 80 mm SL). No consistent increase in infestation rates of bioeroding sponges was detected in pearl oyster shells through time, indicating that rates are fluctuating and long-term data is necessary to determine if infestations by bioeroding sponges are increasing in pearl oyster shells. A very low infestation rate (1.5 %) was found in the habitat of fishing grounds. All other calcareous substrates (excluding pearl oysters) were at least two orders of magnitude more available than pearl oyster shell habitats; however, the estimated areas of infestation were higher in shells than in habitat, indicating a possible preference for pearl oyster shell (Daume et al. 2009).

As part of the project, techniques were also developed for estimating the volume of bioeroding sponge erosions in pearl oyster shells, and detailed recommendations are provided to aid ongoing field surveys and demonstrate the limitations of visual assessments, including an interactive field guide that demonstrates the visual appearance of bioeroding sponge infestations (Daume et al. 2009).

10.1.2 Risk assessment outcomes

The impact of fishing activities on other retained and discarded species have been assessed using a risk based approach (see Section 2.5). The results and justifications of the most recent risk assessment are provided below.

10.1.2.1 Piggyback species

2015 ERA Risk Rating: Loss of habitat for fouling or commensal species (C1 L1 Negligible)

The shell of pearl oysters is encrusted with fouling commensal organisms including other small invertebrates, which use the shell of the pearl oyster as substrate. These organisms are harvested together with the pearl oyster on which they reside and are then scraped off and discarded.

Globally, the types and abundance of fouling organisms on pearl oyster shells have been found to vary both geographically and temporally (Gervis and Sims 1992; Claereboudt et al. 1994); however, several types of fouling organisms (e.g. barnacles, bivalves, tubiculous polychaetes, algae, bryozoans and ascidians) and boring organisms (e.g. polychaetes and sponges) are commonly found on pearl oysters across the geographic regions used for pearl oyster aquaculture (Takemura and Okutani 1955; Dharmaraj et al. 1987; Doroudi 1996; de Nys and Ison 2004) and are likely to be similar to those species found on wild pearl oyster stocks.

Within WA, primary pearl oyster fouling organisms include coralline algae and sponges, with ascidians, fire coral and other algae making up the majority of other fouling organisms. Predatory sponges (e.g. *Cliona* sp.), boring annelids, gastropods and algae can also infest pearl oysters. These species are considered to be wide-spread and can live on a variety of substrates (Enzer Marine Environmental Consulting 1998; Daume et al. 2009). Although some species show a preference for pearl oyster shells, the limited harvest of pearl oysters ensures an adequate level of pearl oyster shells remain within fishing grounds to provide substrate for fouling organisms. Additionally, most harvested pearl oysters are young and contain a limited amount of biofouling compared to the older/larger pearl oysters that remain unharvested.

10.2 Management strategy

There is a strategy in place to manage the impacts of the pearling industry on non-target species, which utilises management measures under the PA, the *Pearling (General) Regulations 1991*(PR) and relevant Ministerial Policy Guidelines as well as other state and commonwealth legislation.

As per the harvest strategy, the POF has the long-term objective for non-target species to *ensure fishing impacts do not result in serious or irreversible harm to bycatch species populations*.

There are a number of measures in place to achieve these objectives (see Section 2.4), including:

- The PA only manages the *maxima* species therefore fishers operating under the PA may only take *P. maxima*;
- Annual catch limits in the form a TAC for *maxima*;
- Gear and fishing method restrictions;
- Size limits for pearl oysters;
- Spatial management via zoning; and
- Statutory reporting of retained catch.

There is high confidence that this strategy will work, based on information about the POF and species involved. No non-target species have been reported with the catch during the history of the POF, as fishers selectively target specific pearl oysters on the seabed. The only other potentially-impacted species are biofouling species that settle on the pearl oyster shells and are collected with the pearl oysters. By limiting the amount and size of pearl oysters that can be removed, a number of pearl oysters are not harvested and remain within fishing grounds, providing sufficient substrate for fouling organisms.

There is clear evidence that the strategy is being implemented successfully and is achieving its objectives. Fishery performance against the objectives in place for non-target species is measured via the Harvest Strategy. Bycatch (non-retained) species have the short-term (annual) objective of maintaining bycatch species above threshold levels (high risk or lower) and close to the target level (moderate risk) (DoF 2016). In the most recent risk assessment (2015), the pearling industry was considered to be a negligible risk to piggyback species populations.

Compliance with management measures is monitored by field officers based in Karratha and Broome, who patrol the entire fishing area (see Section 16.3). Compliance officers utilise diving inspections, aircraft, Departmental patrol vessels and industry boats. Although there has been speculation regarding the recreational take of specimen shells by commercial divers.

10.3 Information and monitoring

The catches of all retained species are reported by all licensees to the Department in statutory *Pearl Oyster Fishery Daily Logsheets* (see example in Appendix E). Catches are verified through the use of quota-associated tags, which are attached to each pearl oyster and verified by processor unloads. In order to ensure quota is not being exceeded, all fishers are issued the same number of tags as their quota limit. Data from these logbooks indicate there have been no non-target species retained by the POF. This information has been verified through compliance checks and monitoring.

11. Endangered, Threatened and Protected Species

11.1 Overview

A number of endangered, threatened and protected¹ (ETP) species can be found within the NCB, including cetaceans, dugongs, marine turtles, sea snakes, crocodiles, elasmobranchs, seahorses and pipefish and migratory sea and shorebirds. These species are protected by various international agreements and national and state legislation. International agreements include:

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

Primary pieces of national and WA legislation include the Commonwealth *Environment Protection and Biodiversity Act 1999* (EPBC), the *Western Australian Wildlife Conservation Act 1950* (WCA), and the *Fish Resources Management Act 1994* (FRMA).

Marine Mammals

Over thirty species of cetaceans have been recorded in the NCB, and the bioregion is thought to be an important migratory pathway between feeding grounds in the Southern Ocean and breeding grounds in tropical waters for several species, including fin, minke and pygmy blue whales. The region is particularly important for the WA population of humpback whales (*Megaptera novaeangliae*), which have known breeding and calving grounds between Broome and the northern end of Camden Sound (DEH 2005; Jenner et al. 2001). Humpback whales can be seen in the northwest region between July and November. The west coast humpback whale population is listed as 'vulnerable' under the EPBC, but data suggests that this population has recovered to 90 % of the pre-whaling-era level (Bejder et al. 2015).

Congregations of whales are generally well-away from pearling and hatchery activities. Possible interactions between the pearling industry and migratory whales may occur in areas

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

² Further information on the CMS, JAMBA, CAMBA and ROKAMBA is provided at www.environment.gov.au/biodiversity/migratory/index.html

such as the Montebello Islands, where the islands are offshore and whales may move through the area. Similarly, individuals may occasionally venture into the nearshore waters of the Kimberley during their migration (IRC Environment 2002).

The DoF has recently completed an FRDC project (2014-004) “Mitigation measures to reduce entanglements of migrating whales with commercial fishing gear”. The project analysed two data sources held by DPAW: the Cetacean Stranding Database and the Commercial Whale Watching Database. The majority of entanglements were associated with the Western Rock Lobster industry although there have been increasing interactions with the Developmental Octopus Fishery. Both fisheries operate off the mid to lower west coast of Australia. The project also developed or amended several logbooks to increase data captured on whale migrations along the WA coast, and also created a smart phone application for sightings. The sightings data will be incorporated into a spatial-temporal model designed to map and predict humpback whale migrations on the west coast of WA.

Dolphins regularly seen in the inshore waters of the region include Australian snubfin dolphins (*Orcaella heinsohni*), Indo-Pacific humpback dolphins (*Sousa chinensis*), common bottlenose dolphins (*Tursiops truncatus*), Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) and spinner dolphins (*Stenella* spp.). The snubfin, Indo-Pacific humpback and the Indo-Pacific bottlenose can be found associated with mangrove systems in nearshore coastal waters. The distribution of each species varies, but all have localised and fragmented populations reflecting the scarcity of appropriate habitat and prey throughout the bioregion (SEWPaC 2012a).

Roebuck Bay is the only area in Australia where snubfin are the most numerous dolphin species, with bottlenose or Indo-Pacific humpback dolphins being more numerous elsewhere. Surveys carried out in Roebuck Bay in 2013 and 2014 estimated the population to be around 140 snubfin dolphins in an area of approximately 100km² (Brown et al. 2014a,b). Genetic studies indicate low levels of movement/migration between snubfin dolphins at Roebuck bay and the nearest reported aggregation at Cygnet Bay (250 km distant).

Dugongs (*Dugong dugon*) can also be found along the Pilbara and Kimberley coasts and are known to occur around the offshore islands of the North West Shelf (Prince 2001). They typically occur in shallow, warm waters over seagrass meadows. Dugongs are susceptible to human-induced pressures due to their longevity (> 70 years), long gestation (12 – 14 months), single offspring, long intervals between births (> 2.5 years) and high age of sexual maturity (Marsh et al. 1984; SEWPaC 2012b). The largest population of dugongs in WA occurs in Shark Bay; however, this population is well outside the geographical area used by the pearling industry. There are no other known areas of major dugong concentrations in WA (IRC Environment 2002).

Marine Reptiles

Six species of marine turtles have been reported in the waters of the NCB: green (*Chelonia mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), flatback (*Natator depressus*), leatherback (*Dermochelus coriacea*), and the occasional olive ridley (*Lepidochelys*

olivacea). The life history attributes of marine turtles (i.e. long lived and slow to mature) make them susceptible to anthropogenic pressures, and high annual survivorship is required to maintain population viability (Lutz et al. 1997). Turtles disperse in the sea for years before returning to their nesting grounds to lay their eggs. Breeding areas throughout the NCB region include Ashmore Reef (green, hawksbill and loggerheads), Browse Island, the Lacepede Islands, the North West Cape, Barrow Island, Muiron Islands and the Montebello Islands (Prince 1994). Turtle nesting occurs from October to February each year, and large turtle rookeries in the region include the Dampier Archipelago, Port Hedland's Cemetery Beach, Eighty Mile Beach, Broome's Reddell Beach and Eco Beach in the Kimberley.

Most of these areas are away from farms leases used by the pearling industry, but farm leases do occur in some areas, such as the Montebello Islands. Individuals are likely to move through farm leases from time to time. As turtles are known to occasionally become entangled in other fishery trap lines, it is also possible that they may become entangled in lines on pearl farms; however, no interactions have been reported to date (IRC Environment 2002).

Sea snakes in the NCB occupy three broad habitat types: shallow water coral reef and seagrass habitats, deepwater soft bottom habitats away from reefs and surface water pelagic habitats (Gunina 2007). Sea snakes are generally long-lived and slow-growing, with small broods and high juvenile mortality (DEWHA 2008). Some species also have very specific diets, which can make them vulnerable to changes in the food web (Fry et al. 2001). Areas in the NCB that are particularly important for some species include the Sahul Shelf (for short-nosed, leaf-scaled, turtle-headed and slender-necked sea snakes); the Pilbara coast (for brown-lined and north-western mangrove sea snakes) and the Kimberley coast (for brown-lined, Stokes', black-ringed and northern mangrove sea snakes; SEWPaC 2012c). Most species in the NCB are not considered to be threatened, with the exception of the short-nosed sea snake (*A. apraefrontalis*), which has recently become scarce, and the leaf-scaled sea snake (*A. foliosquama*).

Both saltwater and freshwater crocodiles can be found within the NCB. Saltwater crocodiles (*Crocodilus porosus*) are natural inhabitants of the coastal waters and estuaries of the Kimberley, and can be found in tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland from the coast (Webb et al. 1987). Saltwater crocodiles are estimated to live up to 70 years or age and can grow up to eight metres long (Webb et al. 1984). Before 1970, saltwater crocodiles were hunted, and populations dwindled (Fukuda et al. 2007); however, as a result of protection, the total Australian non-hatchling seawater crocodile population has dramatically risen to approximately 100 000 – 200 000 individuals (Fukuda et al. 2007). Freshwater crocodiles (*C. johnsoni*) are endemic to Australia and only occur in the tropics (Webb and Manolis 1989). They prefer upstream freshwater areas and can be found in lakes, rivers and billabongs.

Saltwater crocodiles are likely to interact with farm leases, as they are common in inshore, mangrove areas. Crocodiles pose a danger to people on the farm leases, and their presence is closely monitored (IRC Environment 2002).

Protected Fish Species

A number of syngnathids and solenostomids (seahorses, pipefish and ghost pipefish) can be found throughout the NCB. Syngnathids generally have diverse characteristics, ranging from rare and localised species to widely distributed and very common. Syngnathids are usually found in shallow, coastal waters living among seagrasses, mangroves, coral reefs, macroalgae-dominated reefs and sand / rubble habitats (Dawson 1985; Vincent 1996; Lourie et al. 1999, 2004).

Elasmobranch species found in the NCB include grey nurse sharks, whale sharks, mako sharks, *Glyphis* sharks, and sawfish. Generally, elasmobranchs are characterised by their conservative life history characteristics (late age at maturity, slow growth rate, low fecundity, extended longevity and low rate of natural mortality) which result in restricted productivity (DEWHA 2008).

The coastal waters of the Pilbara and western Kimberley are considered to be a global hotspot for sawfish diversity, with four of the world's five species found there, including the largetooth sawfish (*Pristis pristis*), dwarf sawfish (*Pristis clavata*), green sawfish (*Pristis zijsron*) and narrow sawfish (*Anoxypristis cuspidata*). Sawfish generally inhabit inshore coastal and estuarine environments (SEWPaC 2013) and are easily identified by the presence of a blade-like snout with enlarged tooth-like denticles known as rostral teeth (Last and Stevens 2009). Globally, sawfish have undergone major declines in both range and abundance, partially from their vulnerability to entanglement in fishing nets, but also through loss of habitat (Morgan et al. 2010). Local population size within the NCB is unknown, although collective evidence has demonstrated a large decline in *Pristis* spp. in Australian waters in the last 15 – 20 years (Giles et al. 2006). There is limited information on the size of remaining populations, and many are thought to survive in small fragmented areas (Morgan et al. 2010).

Sea and Shore birds

The NCB has two coastal areas of international significance, both covered by the Ramsar Convention: Roebuck Bay and Eighty mile Beach. Both sites have large intertidal mudflats, containing a high density of invertebrates and are the primary feeding grounds and overwintering areas for Palaearctic shorebirds on their annual southwards migrations.

The Roebuck Bay Ramsar site covers an area of 34,119 hectares and supports more than 1% of the international population of at least 22 species of shorebird, 20 of them migratory. The area is regularly home to over 100,000 shorebirds, with the total number of birds using the site as a summer stop-over in any one calendar year estimated to exceed 300,000 (Bennelongia 2009, Roebuck Bay Working Group 2009).

The Eighty mile beach Ramsar site comprises of two separate areas: 220km of beach and associated intertidal mudflats and Mandora Salt Marsh 40km inland. Eight Mile Beach supports more than 1% of the international population of 21 waterbirds, including 17 migratory species and 4 Australian residents. To date over 100 species of birds have been recorded at the beach, including 97 waterbirds and 42 species of migratory shorebird. The site

is considered one of the most important in Australia for numbers of shorebirds supported and regularly supports in excess of 500,000 birds. There is a record of 2.88 million Oriental Pratincoles on the beach in February 2004 (Hale and Butcher 2009).

The NCB is also important for many seabird species including terns, petrels, shearwaters, tropic birds, frigatebirds and boobies. Sea and shorebirds generally have low fecundity, are long-lived, display site fidelity and are highly vulnerable to introduced predators (SEWPaC 2012d).

11.2 Pearling industry impacts

The selective nature of the fishing methods (hand collection by divers) minimises the risk of interactions with ETP species and there have been no interactions with any ETP species reported in the POF.

Following seeding, the pearl oysters are grown-out on farm leases with the majority situated in sheltered bays along the Kimberley coast north of Broome and the NT coast. These farm leases do not overlap normal migration paths of whales along the NT and WA coastlines, which are generally further offshore. In the more than five decades of the Australian *P. maxima* pearling industry, there have been only two humpback whale interactions on farm leases. On both occasions the whale was successfully released. There have been no recorded entanglements of other ETP species (PPA 2008).

The POF has been assessed under the provisions the EPBC (Part 13 and 13A; see Section 2.5.3), part of which considers the effects of the POF on ETP species. In the most recent assessment in 2015, the POF was considered not likely to adversely affect the survival or recovery of any listed threatened species.

11.2.1 Risk assessment outcomes

The impact of fishing activities on ETP species have been assessed using a risk based approach (see Section 2.5). The results and justifications of the most recent risk assessment are provided below.

11.2.1.1 Whales and dolphins

2015 ERA Risk Rating: Impact of fishery boat strikes on whale and dolphin populations (C1 L1 Negligible)

2015 ERA Risk Rating: Impact of entanglements in culture lines on whale and dolphin populations (C1 L1 Negligible)

11.2.1.2 Crocodiles

2015 ERA Risk Rating: Impact of fishery boat strikes on crocodile populations (C0 L0 Negligible)

2015 ERA Risk Rating: Impact of entanglements in culture lines on crocodile populations (C0 L0 Negligible)

11.2.1.3 Marine turtles

2015 ERA Risk Rating: Impact of fishery boat strikes on marine turtle populations (C1 L1 Negligible)

2015 ERA Risk Rating: Impact of entanglements in culture lines on marine turtle populations (C0 L0 Negligible)

11.2.1.4 Sharks and rays

2015 ERA Risk Rating: Impact of entanglements in culture lines on shark and ray populations (C0 L0 Negligible)

11.3 Management strategy

There is a strategy in place to manage pearling industry-related impacts on ETP species, which utilises management measures under the PA, the PR and relevant Ministerial Policy Guidelines as well as other state and commonwealth legislation. As per the harvest strategy, the POF has a long-term objective for ETP species *to ensure fishing impacts do not result in serious or irreversible harm to ETP species populations*. There are a number of legislated measures in place to achieve this objective, including:

- Requirement to collect pearl oysters by hand while diving;
- Spatial management of the POF via zoning; and
- Statutory reporting of all ETP species interactions.

The pearling industry, through the PPA, has also established a number of initiatives to minimise and monitor impacts, including the implementation of an industry *Environmental Code of Conduct*. The *Environmental Code of Conduct* includes a number of activities to guide best environmental practices including: (1) protecting the environment; (2) complying with regulations; and (3) treating aquatic animals responsibly (PPA 2008b). The PPA has also developed a *Pearling Industry Whale Management Policy and Protocol* (see Appendix I). This document establishes a policy and response protocol to deal with a whale interaction, should one occur. The policy outlines the pearling industry commitments, including:

- Adopting a cooperative whole-of-industry approach to preventing interactions;
- Adopting an agreed protocol in response to interactions, especially entanglements, should they occur, including the emergency contact details of appropriate authorities;
- Reporting interactions immediately as rapid reporting ensures response teams have the best possible chance of success;
- Monitoring, on a regular basis, all pearling longline systems and mooring ropes to maintain integrity;
- Where possible, removing any potential sources of entanglement from the marine environment;
- Where appropriate and cost effective, making use of technological assistance that may reduce the likelihood of an interaction;

- Ensuring the safety of personnel should entanglement occur until trained response teams arrive; and
- Voluntary participation of industry personnel in Department of Environment and Conservation (currently DPaW) disentanglement training programs.

This protocol provides for direct pearling industry involvement in the reduction of whale interactions by adopting ‘best practice’ at an industry level (PPA 2008a).

P. maxima is only one species targeted by the POF, with individuals collected by hand by highly-trained divers as they are towed over the seafloor. There are a small number of vessels operating in the fishery (6 – 10 annually), which each tow up to six divers at a time. This fishing method and small number of boats in the water reduces the likelihood of ETP interactions, and no interactions have been reported throughout the history of the POF.

Potential impacts on marine mammals as a result of aquaculture interaction include death or injury through entanglement in gear (Dans et al. 1997; Kemper & Gibbs 2001; Crespo & Hall 2002; Hall & Donovan 2002), displacement, disruption of migration pathways (Crespo & Hall 2002; Würsig & Gailey 2002; Markowitz et al. 2004; Watson-Capp & Mann 2005) and human intervention, i.e. animals are killed or relocated. Farm leases used by the pearling industry in WA are generally manned at all times (cyclones permitting). Pearl oysters are held in net panels just below the surface, attached to surface longlines that are anchored at each end. The longline system is designed to allow the panels to move with the tide and the pearl oysters to feed in as close as possible to their natural state. Unlike fish farms that are netted at the periphery, the pearl oyster farm leases have large open areas that small cetaceans can swim through, although some individuals may simply avoid the farm all together because of the equipment, human activities or other factors (Watson-Capp & Mann 2005). The layout of the farm leases and use of surface longlines reduces the number of lines in the water and thus, the potential for whale entanglements. In the rare event that an entanglement should occur, the *Pearling Industry Whale Management Policy and Protocol* outlines appropriate action that should be taken. On the two occasions where an entanglement has occurred, the whales were successfully released (PPA 2008a).

Fishery performance against the objective for ETP species is measured and monitored annually via the harvest strategy. The POF has a short-term (annual) objective for ETP species that *fishery impacts are considered to generate an acceptable level of risk (i.e. moderate risk or lower) to all ETP species populations* (DoF 2016). In the most recent risk assessment (2015), the POF was considered to be a negligible risk to ETP species populations.

The potential effectiveness and practicality of alternative measures to minimise industry-related mortality of ETP species is reviewed regularly and are implemented as appropriate. The Department and pearling industry undertake regular (approximately every five years) reviews of the risk to ETP species from pearling industry operations. Where a risk is considered undesirable (e.g. has increased from low to medium or is assessed as high), new and/or further risk control measures are investigated and implemented, with a goal of reducing the risk to an acceptable level.

11.4 Information and monitoring

Quantitative information is available to assess the fishery-related impacts, mortalities, injuries and consequences for ETP species. Fishers in the POF have a statutory requirement¹ to report all ETP species interactions to the Department in daily logbooks (see Appendix E). All CAES returns are checked by Departmental staff, and any possibly erroneous entries or gaps are verified directly with skippers or the fishing company. Protected species interactions should also be reported directly to DoTE or the Department of Parks and Wildlife (DPaW) as relevant.

This information is used to inform fishery performance against the ETP species component of the Harvest Strategy. Information on the number of interactions with ETP species is used to inform periodic risk assessments undertaken, with specific control rules in place for different risk ratings. Although risk assessments are scheduled to take place every five years, they can be triggered following a substantial change in operations or management or the reporting of an unusually high number of interactions, which may indicate a significant change in the previous assessment outcomes.

¹ Note prior to 2017 fishers were required to report any ETP species interactions in the ‘comments’ section of daily logbooks; this is being modified to include a specific section for reporting ETP species interactions.

12. Habitats

12.1 Overview

The pearling industry extends from Exmouth Gulf north to the NT border, although the majority of activities occur in the NCB along the Pilbara and Kimberley coastal regions. Harvesting of wild pearl oysters occurs mainly off 80 Mile Beach and a channel between the mainland the Lacepede Islands at approximately 10 – 20 m depths (Figure 12.1).

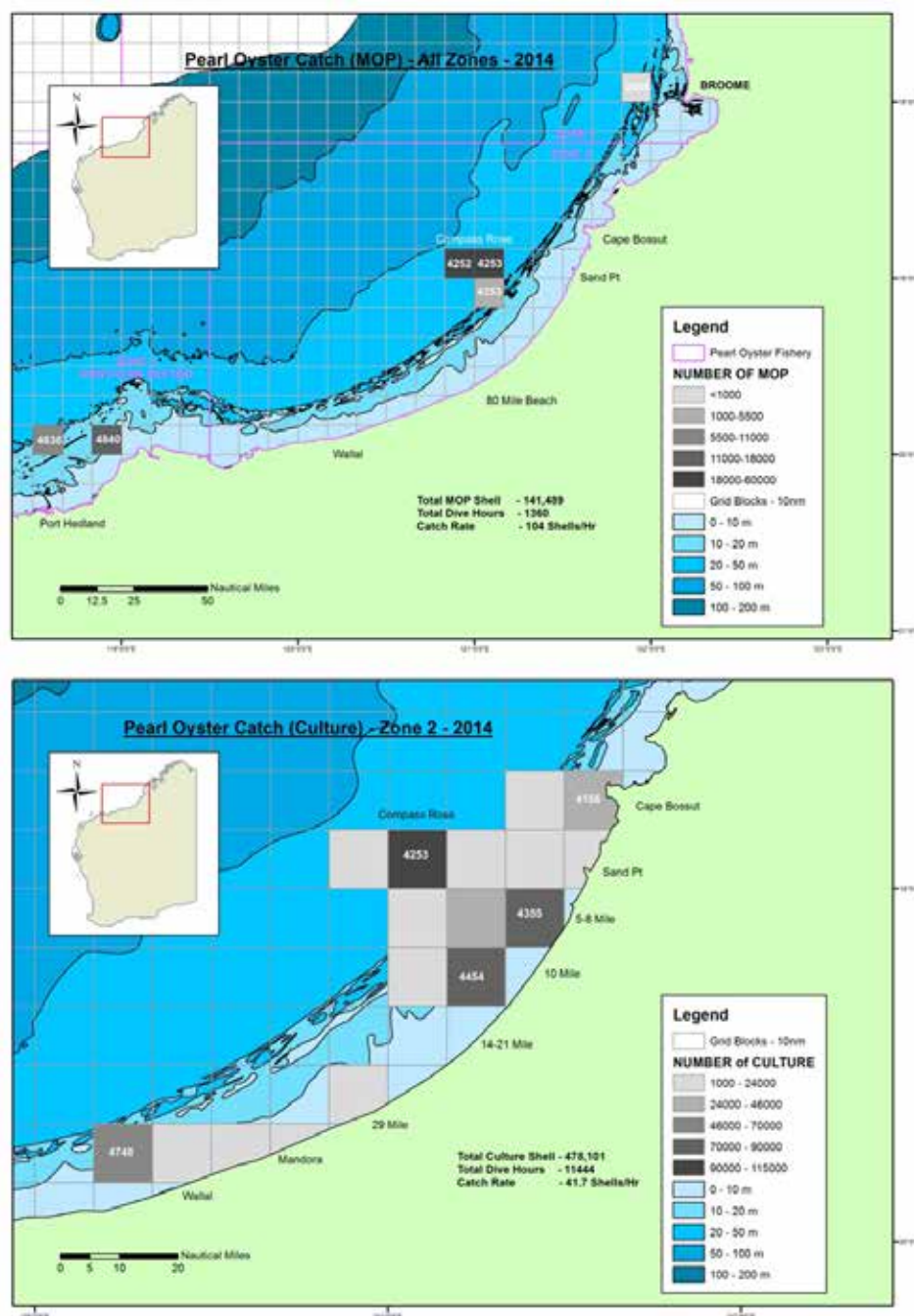


Figure 12.1 Distribution and intensity of fishing effort in the POF for larger pearl oysters used for Mother of Pearl (MOP) (top) and culture pearl oysters (bottom).

Pearl farming primarily takes place in relatively sheltered waters, although in recent years some companies have also started farming pearls in open water areas off the west coast of the Dampier Peninsula around Quandong and James Price Point (see Figure 2.3).

12.1.1 Exmouth Gulf

Water depths in Exmouth Gulf range from approximately five metres along the sloping southern and eastern shores to ~ 20 m in the northern and western regions. Rainfall in the region is extremely low and, coupled with minimal river flow entering the Gulf, creates a relatively stable hydrological environment (Penn & Caputi 1986). This changes, however, with the seasonal occurrence of tropical summer cyclones, which can bring extreme winds, heavy rainfall and increased runoff, altering salinity and turbidity within the Gulf. The warm waters of the Leeuwin Current affect the offshore waters of Exmouth Gulf, particularly during strong winter flows. This warm current maintains elevated water temperatures, depressed levels of dissolved nutrients and particle concentrations, and inhibits the growth of macroalgae (Hatcher 1991). Consequently fisheries production relies on nutrient sources from benthic habitats in near-shore waters, rather than from oceanic ecosystems (Lenanton et al. 1991). Key habitats within the Gulf include mangroves, intertidal mudflats, coral reef, seagrass and mud / sand bottom areas. The Gulf supports a number of tropical fish and invertebrate species, as well as protected species such as dolphins, marine turtles, elasmobranchs (e.g. sawfish), sea snakes and sea horses and pipefish.

The western shore of Exmouth Gulf is comprised of dune-backed beaches and sandy, shallow subtidal regions with a few rocky outcrops. There are narrow bands of coral reef at the northern end (Bundegi Reef) and near the southern end of the Gulf (Point Lefroy to Roberts Island). Sub tidally, there is a rich growth of hard corals, although only 28 species have been recorded in the area (Veron and Marsh 1988). In contrast, extensive muddy salt flats, up to 10 km wide, border the southern and eastern shores of the Gulf (McCook et al. 1995; Morrison et al. 2003). The shallows, particularly in the southern region, have very little vegetation, and some areas are completely bare and consist only of sand and gravel (Morrison et al. 2003). The intertidal mudflats are lined with dense mangrove stands, mainly *Avicennia* and *Rhizophora* spp., which make up one of the largest mangals in WA (Johnstone 1990; Wilson 1994). The mangrove stands are the most extensive along the eastern shores of the Gulf (Johnstone 1990).

In the shallow waters of the Gulf fronting the mangals, extensive seagrass beds provide feeding habitats for turtles and dugongs (Wilson 1994). All of the seagrass species found in the Gulf are all of a tropical distribution and are found in very low abundances, rarely exceeding 5 – 10 % cover. Small amounts of algae (e.g. *Caulerpa*, *Halimeda*, *Udotea* and *Penicillus* spp.) have been found mixed with these seagrass beds, and large quantities of filamentous turfs, ephemeral epiphytes and perennial macrophytes, such as *Sargassum* spp., are also frequently found attached to or tangled with the seagrasses. In some places, particularly the central eastern coast, the cover and biomass of these algae exceed that of the seagrasses. On the west coast, seagrasses are more patchily distributed and do not occur

below eight metres, although brown algae, e.g. *Sargassum* spp., are present down to 10 m (McCook et al. 1995). The low abundance of seagrass within the Gulf has been attributed to the lack of suitable substrate, with observed substrate consisting of either hard or mobile coarse sediments. Despite the low seagrass abundance, Exmouth Gulf is a highly productive ecosystem, with macroalgae, phytoplankton and salt-flat cyanobacteria the main primary producers (McCook et al. 1995).

Extensive vegetated (ephemeral seagrasses, sponges and macroalgae) shallow banks, extending predominantly south of Hope Point on the eastern coast of the Gulf, can be found generally 0.5 – 1.5 m below mean sea level and support the majority of marine fauna in the area (Straits Salt Pty. Ltd. 2006). These banks are a key component for the life cycle of prawns, and trawling is prohibited in the southern and eastern areas of the Gulf to protect this important nursery area.

The majority of the flora and fauna in the Gulf are tropical, but some subtropical and temperate species are also present (Hutchins 1994). Limited information is available on the extent and type of soft sediment that covers a large part of the central seabed in Exmouth Gulf or its associated fauna. Apache Energy (1998) report that soft sediment regions above 20 m depth outside commercial trawl areas have extensive invertebrate communities, of which the most abundant are echinoderms including sand dollars, *Diadema* urchins, heart urchins and crinoids, plus some areas have abundant solitary corals. The channel between the Muiron Islands and North West Cape has only a thin veneer of coarse sediment overlying limestone pavement. This area is rich in gorgonians, sea whips, bryozoans, some hard corals, crinoids, ascidians and hydroids, but few fish species were recorded (Apache Energy 1998).

12.1.1.1 Habitat mapping

Habitat data for the North West Shelf region from North West Cape to Port Hedland, including Exmouth Gulf has been integrated to produce maps and descriptions of key ecosystems in the region as part of the North West Shelf Joint Environmental Management Study (NWSJEMS; Lyne et al. 2006). Habitat maps were derived mainly from already existing information, but survey fieldwork was also undertaken were needed to fill critical gaps in spatial coverage.

Two “levels” of habitat maps relevant to the consideration of potential fishery impacts in Exmouth Gulf were created (1) biogeomorphological units, habitat structures represented by “fields of features” and (2) primary biotopes, relatively uniform habitats. There were 12 biogeomorphological units identified within Exmouth Gulf (Table 12.1; Figure 12.2; Lyne et al. 2006).

Table 12.1. Biogeomorphological units identified by Lyne et al. (2006) within Exmouth Gulf

Geographic Unit	Description
Beach – Dune	Sandy beaches or dune shorelines above the mean water level (does not differentiate sandy substrate in the marine environment)
Sand flats – tidal flats	Landward extent of tidal zone inundated only at high tide or during elevated tidal events such as cyclones
Mud and tidal flats	Tidally inundated; intertidal zone
Mangroves	Occurrence of mangroves or mangals. Mangroves recognised as unique subset of the mud and tidal flats
Embayment – subtidal zone	Shallow water enclosed by an embayment that is not exposed at low tide
Tidal channel (subtidal)	Tidal drainage channel/s that incise tidal flats and may extend inland to form tidal creeks through coastal tidal or mud flats
Nearshore waters (< 5 m)	Undifferentiated shallow nearshore and coastal waters which are not tidally exposed
Nearshore Reef	Areas identified as reef, adjacent (connected either directly or adjacent to mudflats) to the mainland coastline or islands
Offshore waters (5 – 10 m)	Offshore waters between 5 and 10 m depth; includes water surrounded by deeper water (> 10 m)
Offshore waters (10 – 20 m)	Offshore waters between 10 and 20 m depth
Shallow island fringe	Shallow, intertidal waters adjacent to islands. Less than 5 m depth.
Offshore waters < 5 m (island, shoal)	Shallow water in areas deeper than 5 m which are less than 5 m deep; may represent shoals or reefs on navigation charts and are not surrounding or adjacent to islands

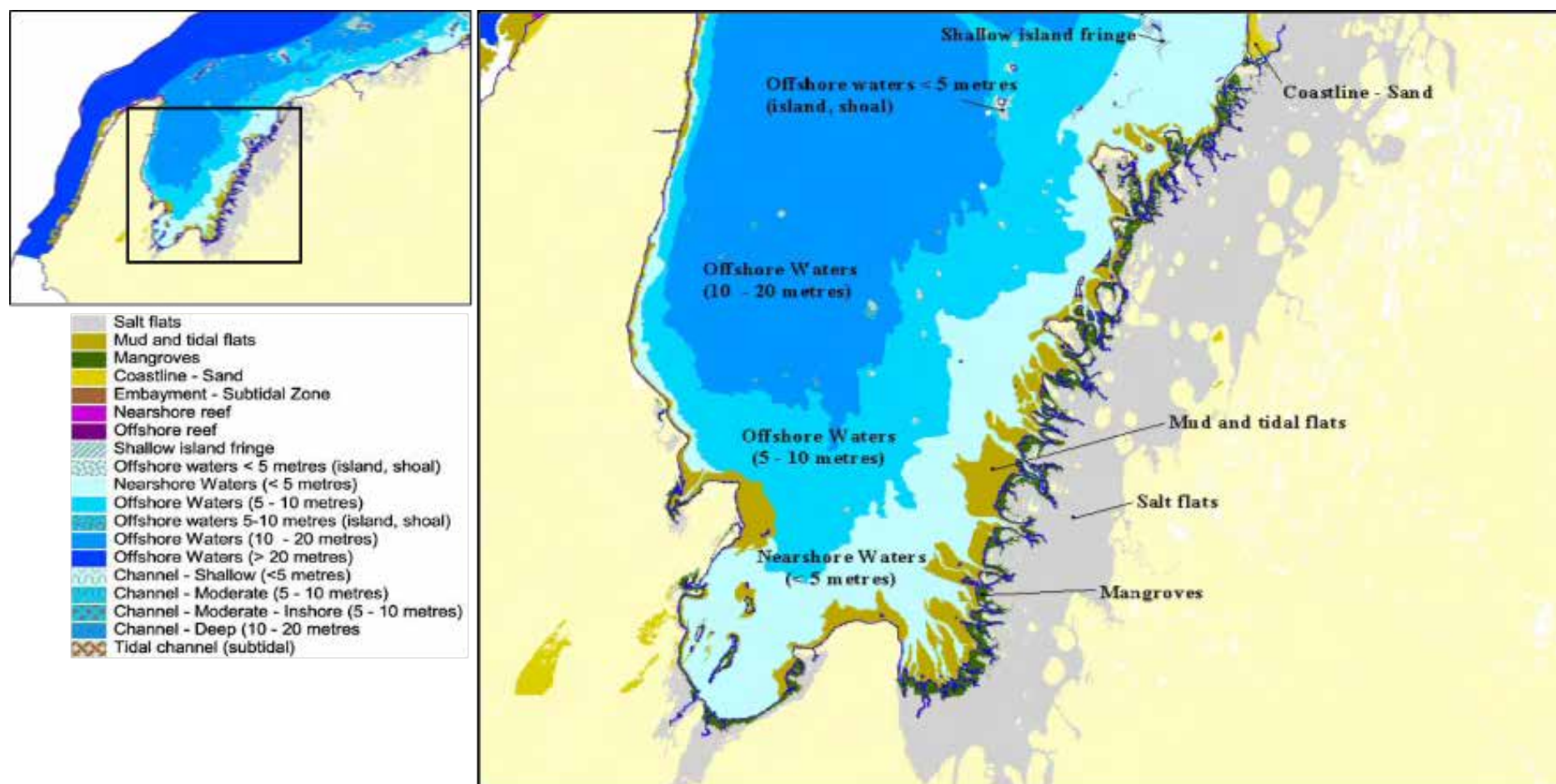


Figure 12.2. Biogeomorphic units of Exmouth Gulf (Source: Lyne et al. 2006)

Additional information was obtained on marine habitats in some areas, which allowed for the extension of the hierarchical classification to Level 4 (primary biotopes). This information was compiled from existing habitat mapping and inferred where data did not exist (Figure 12.3).

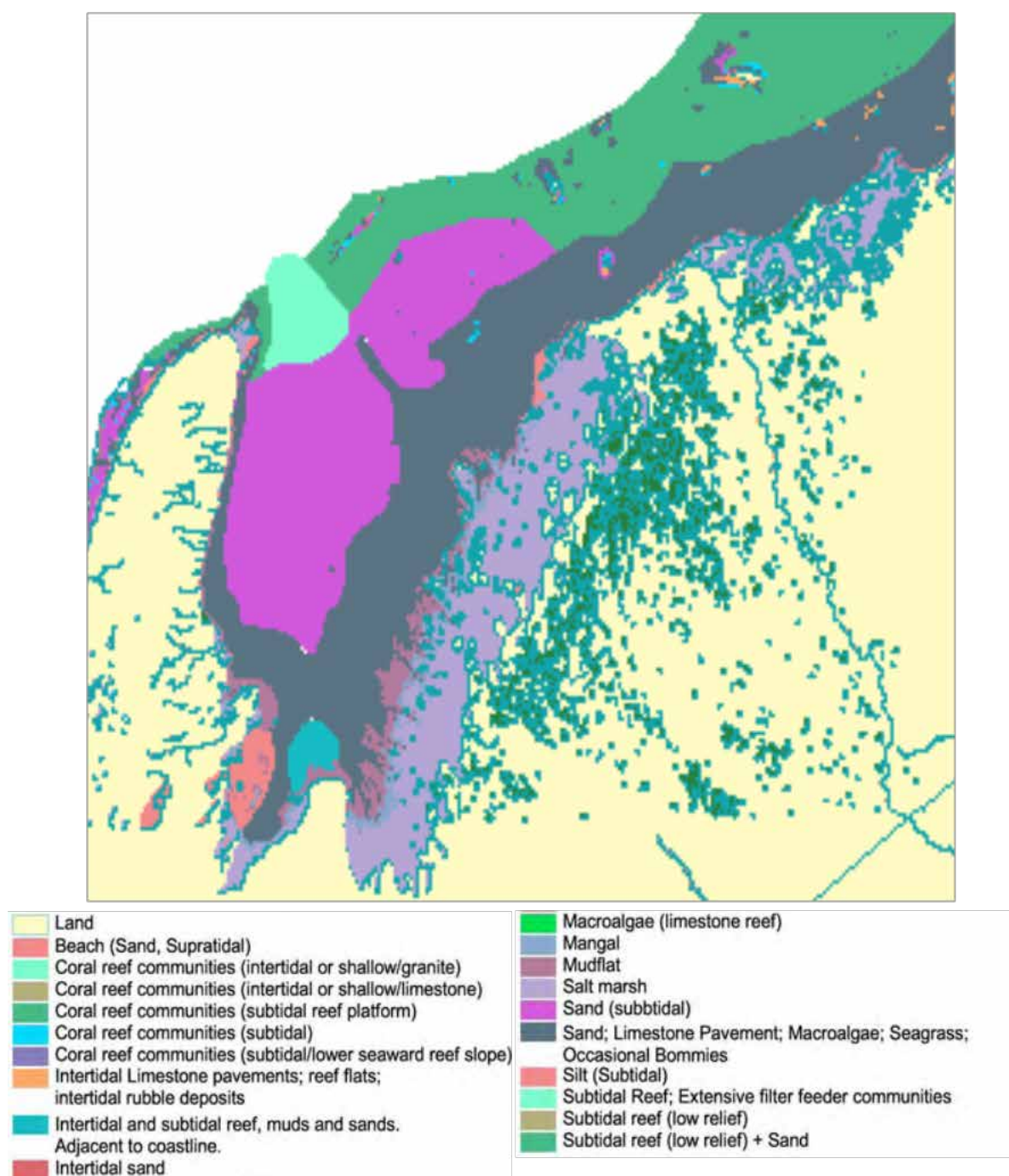


Figure 12.3. Primary biotopes of Exmouth Gulf region (Source: Lyne et al. 2006)

12.1.2 Pilbara Coast

The Pilbara coast is a low-energy coast with an arid to tropical climate. There is a pronounced dry season typically experienced from August to November (Wilson 1994). Sea surface temperatures range from 18° C in winter to 32° C in summer (Department of Conservation and Land Management [CALM] 2005). Average annual rainfall along the

Pilbara Nearshore Ecosystem (PNE) is between 250 and 350 mm but is very erratic. Most rainfall occurs between January and May, mainly as a result of tropical cyclones and depressions (NWSJEMS 2007). Tropical cyclones occur most frequently from November through May, and two to three cyclones could be expected to pass through an area in any one year. Cyclones are known to cause considerable damage to nearshore habitats due to wave action, sedimentation and high turbidity (CoA 2007; URS 2008). Cyclones also give rise to large inputs of freshwater and sediment, which is significant as this region receives little run off at other times (CoA 2007).

The marine environment is characterised by a large tidal range, resulting in highly turbid water and low wave energy in the nearshore environment (< 10 m depth), with clearer water and more moderate wave energy as depth increases (CALM 2005; IMCRA 1998). Barrier islands and associated protected lagoons, embayments and deltas dominate the coastline, and there is a series of limestone islands (i.e. the Muiron, Serrurier, Besieges, Thevenard, Rosily, Barrow and Montebello Islands) just inside the 20 m bathymetric contour (CALM 2005).

Although the Indonesian Throughflow generally suppresses upwellings along the coast, there are some localised areas of enhanced biological productivity (CoA 2007). The processes underlying this productivity are unclear, although productivity may be associated with a unique combination of bathymetry and oceanography, where a strong current running along the coastline interacts with the 50 m contour line which runs perpendicular to the coast. This interaction is likely to cause mixing of deeper, more nutrient-rich water with surface waters. Localised upwellings are also thought to occur around Browse Island and attract large aggregations of marine species, including cetaceans (DEWHA 2008).

The majority of the marine species in the Pilbara are tropical, and the region hosts a variety of corals, fish, molluscs and other invertebrates. A number of larger marine animals, such as whales, dolphins, dugongs and marine turtles can also be found throughout the ecosystem.

Coastal and shallow water habitats along the Pilbara coast include mangrove forests, macroalgae and seagrass beds and fringing coral reefs around some of the nearshore islands (CALM 2005; NWSJEMS 2007). Variation in coastal habitat occurs on a north-south gradient; the area between Onslow and Cape Keraudren comprises a mangrove coast underlain by limestone platform, with some freshwater input via river run off, while between Cape Keraudren and the northern limit of Eighty Mile Beach, the coast is sandy and dry and receives little freshwater input (CoA 2007).

The marine habitats of the Pilbara coast are considered to be in relatively pristine condition; however, there are localised areas of species and habitat depletion (CALM 2005). Algae and coral are dominant on shallow sandbars, platforms, reefs and ridges in the southern section of the region, although patchy seagrasses can also be found on the limestone flats. Algae are thought to be the primary producer in this system, followed by mangroves and corals in isolated areas (CoA 2007).

Several types of coral reefs characterise the coral communities of the Pilbara coast, which comprise both turbidity-adapted communities of inshore environments and offshore, clear-

water coral communities. Scleractinian corals can be found in the turbid nearshore waters, although most coral reefs are developed around the more distant islands, notably those in the Dampier Archipelago (IMCRA 1998). In the West Pilbara, offshore coral banks and platform reefs are predominant, whereas around the Dampier Archipelago, the Montebellos, the Muirons and other offshore islands, extensive fringing reefs dominate (Department of Environment 2006). The seaward sides of the Muiron and Barrow Islands also have intertidal rock platforms, a habitat not found in the nearshore area (CALM 2005).

Structurally complex mangrove forests (mangals) are a dominant feature of the mainland shore, with lesser systems around the islands. Despite their complexity, the mangals have low species diversity (seven species of mangrove), which is possibly related to the semi-arid climate. There are few places in the world where mangals occur in arid conditions, making those in the Pilbara of scientific importance (IMCRA 1998). Wide supra-tidal flats occur behind most of the mainland mangals, and there is extensive development of intertidal mud and sand flats seaward of the mangals. Burrowing infauna is abundant and diverse in these areas, providing an important food source for migratory birds (IMCRA 1998).

Historically, this region is considered to have contained significant sponge habitats, although these have been damaged by trawling activities. There is some evidence of recovery in the northern section, although there is still a general lack of information about sponge composition and distribution throughout this region (CoA 2007).

12.1.2.1 Habitat mapping

A significant portion of the Pilbara coastal marine habitat has been mapped to describe both the physical substratum and the biologically communities. This is largely the result of different government agencies and private sectors undertaking habitat mapping exercises in relation to coastal development projects and marine reserve planning initiatives. The information available has been collected using a variety of methods and at different spatial scales; however, habitat classification categories have been similar, providing an overview of the benthic habitats found in the region.

Detailed marine habitat mapping for most of the PNE has been conducted as part the NWSJEMS. Habitat data was integrated to produce maps and descriptions of key ecosystems for the inshore North West Shelf region from North West Cape to Port Hedland (Lyne et al. 2006). The habitat maps were derived mainly from already existing information, but survey fieldwork was undertaken where needed to fill critical gaps in spatial coverage. Maps were created at four classification levels: (1) provinces, the largest spatial scale reflecting paleo-historic evolutionary processes; (2) biomes, representing habitat structures responding to the largest environmental gradients; (3) biogeomorphical units, habitat structures represented by 'fields of features' or large geomorphic structures such as gulfs, bays or plateaus; and where data was adequate, (4) primary biotopes, uniform environmental conditions providing habitat for a specific assemblage of plants and animals (Lyne et al. 2006).

Level 3C units represent the major coastal and nearshore geomorphic units and were the best unit for mapping available across the entire study region at a similar scale. Nineteen level 3C

units were identified along the Pilbara coast (Table 12.2; Figure 12.4). Additional information was obtained on marine habitats in some areas which extended the hierarchical classification to Level 4. This information was compiled from existing habitat mapping and inferred where it did not exist, and the classification was applied across the North West Shelf study region (Figure 12.5).

Table 12.2. Mapping units identified at Level 3C. Source: Lyne et al. (2006)

Geographic unit	Description
Land/island	Mainland, islands
Beach-dune	Sandy beaches or dune shorelines above the mean water level.
Salt flats- tidal flats	Landward extent of tidal zone inundated only at high tide or during elevated tidal events such as cyclones.
Mud and tidal flats	Tidally inundated. Intertidal zone.
Mangroves	Occurrence of mangroves or mangals. Mangroves are recognised as a unique unit as a subset of the mud and tidal flats.
Embayment – subtidal zone	Shallow waters enclosed by an embayment which are not exposed at low tide.
Tidal channel (subtidal)	Tidal drainage channel/s which incise tidal flats and may extend inland to form tidal creeks through coastal tidal or mud flats.
Nearshore waters (< 5 metres)	Undifferentiated shallow nearshore and coastal waters which are not tidally exposed.
Channel (< 5 metres)	Channel in coastal waters separating islands less than 5 metres deep. Does not include extensions of coastal creeks.
Channel (5 to 10 metres)	Channel 5 to 10 metres deep separating islands or islands from mainland.
Channel (10 to 20 metres)	Channel 10 to 20 metres deep separating islands or islands from mainland.
Nearshore reef	Areas identified as reef, adjacent (connected either directly or adjacent to mudflats) to the mainland coastline or islands.
Offshore reef	Areas identified as reef not immediately adjacent to mainland coast or island. Generally in waters deeper than 5 metres.
Offshore waters (5 to 10 metres)	Offshore waters between 5 and 10 metres depth. Includes water surrounded by deeper waters (> 10 metres).
Offshore waters (10 to 20 metres)	Waters between 10 and 20 metres depth.
Offshore waters (> 20 metres)	Waters greater than 20 metres deep.
Shallow island fringe	Shallow waters adjacent to island which are intertidal. Less than 5 metres depth.
Offshore waters < 5 metres (island, shoal)	Shallow water in areas deeper than 5 metres which are less than 5 metres depth. May be represented as shoals or reefs on navigation charts, or shallow waters in bathymetric charts. Not surrounding or adjacent to islands.
Offshore waters 5 to 10 metres (island, shoal)	Shallow water in areas of water deeper than 10 metres which are between five and 10 metres deep. May be represented as shoals or reefs on navigation charts.

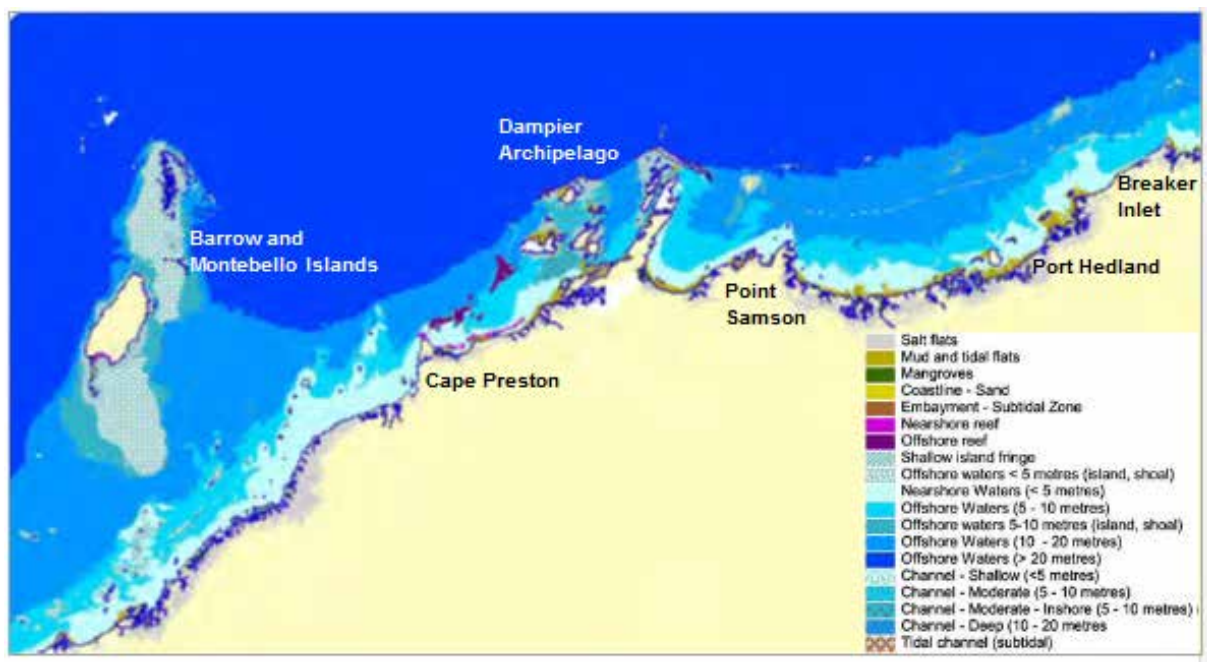


Figure 12.4. Level 3C units for the Pilbara Coast from Onslow north to Breaker Inlet.
Source: Lyne et al. (2006)

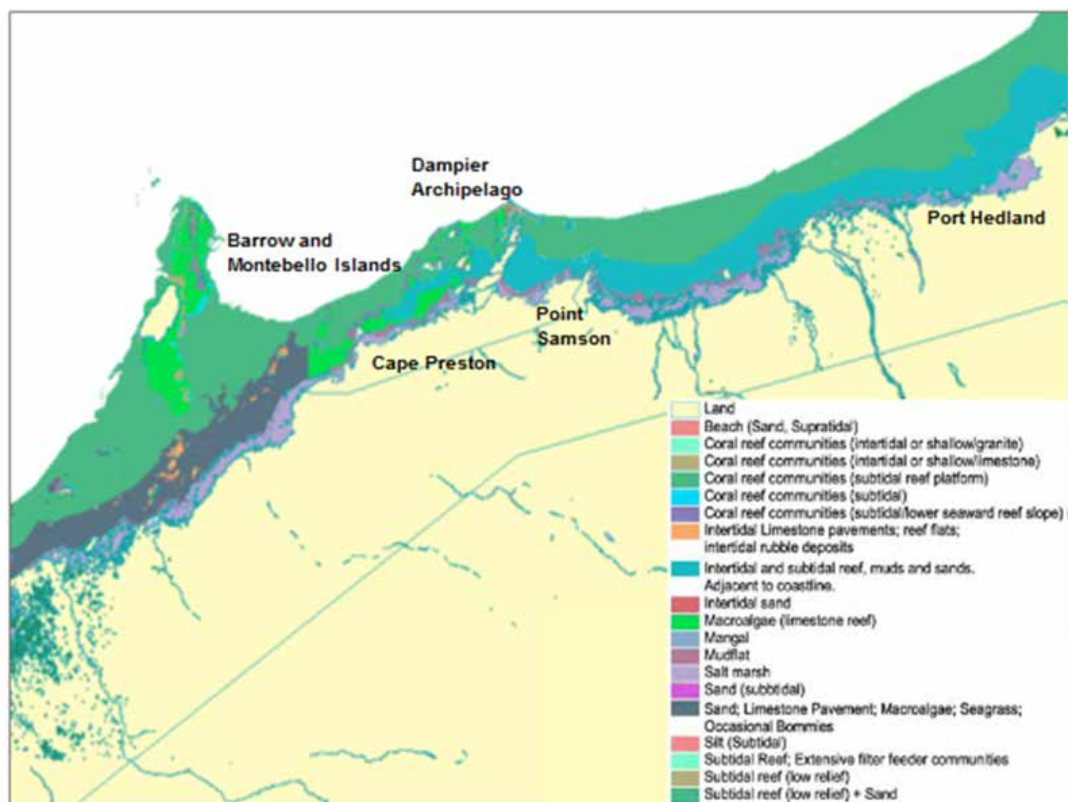


Figure 12.5. Map of Level 4 habitats for the Pilbara Coast from Onslow north to Breaker Inlet.
Source: Lyne et al. (2006)

12.1.3 Kimberley Coast

The Kimberley coast is one of the most remote and inaccessible stretches of the Australian coast, extending for a distance of over 1000 km, much of which is uninhabited. Broome and

Derby in the west and Wyndham in the east are the only major coastal settlements. There are no roads accessing the coast between Derby and Wyndham (except four-wheel drive tracks), and the only settlements are small towns on Koolan and Cockatoo Islands and at Kuri Bay and Aboriginal communities (Wilson 1994). Due to this lack of development and isolation, the Kimberley marine environment is recognised as among the world's most pristine and ecologically diverse (Masini et al. 2009).

The Kimberley coast is a large-scale ria-type coast with its many gulfs, headlands, cliff-lined shores and archipelagos. In the approximately 500 km direct line from the Yampi Peninsula to the King Edward River near Kalumburu, there are ~ 12 850 km of coastline, including 2581 islands (Masini et al. 2009). This represents 40 % of the entire length of the WA coastline (Northern Development Taskforce [NDT] 2008). The coast is not just a continuous rocky shore, however, as it also has local sediment-filled gulfs and embayments, cliff shores fringed by mangroves, stretches of beaches and in the embayments, muddy tidal flats, spits, cheniers, tidal creeks and alluvial fans (Brocx and Semeniuk 2011).

The region experiences a tropical monsoonal climate, with a wet season from November to March and a dry season from April to October. Monthly temperatures range from 25 – 35° C. Annual rainfall ranges from 1500 mm in the north-west to 350 mm in the semi-arid south and occurs mainly during the wet season. The tides increase in amplitude from north to south, and can be up to 11 metres during some spring tides in the King Sound and Yampi Peninsula areas (NDT 2008; Masini et al. 2009). Other areas along the north coast, however, have much smaller tidal ranges (~ 3 m). Cyclones are inter-annual and restricted to the summer season. The effects of cyclones are highly localised and can result in high seas, large waves and storm surges (Lourensz 1981; Lough 1998).

The marine species in the Kimberley region are tropical and while many are widespread throughout the Indo-Pacific region, several are unique to the Kimberley. In addition to the diversity of corals, fish, molluscs and other invertebrates, the region also hosts a wide variety of larger marine animals such as whales, dolphins, dugongs, crocodiles and marine turtles.

The large tidal amplitudes and the extensive and complex coastline combine to produce ecologically diverse and highly productive intertidal areas ranging from cliffed coasts to wide expanses of mud flats, sand banks, coral and algal reef flats, mangrove forests and beaches (Masini et al. 2009). Subtidal habitats include macroalgal reefs, corals, seagrass and filter-feeding communities. Mangrove communities are well developed along the Kimberley coast and are considered to be relatively pristine (Wilson 1994). The region has a range of habitats for mangroves and depending on the coastal type, mangroves form habitat-specific assemblages (Cresswell and Semeniuk 2011). The mangroves of the region have been moderately well studied (e.g. Thorn et al. 1975; Semeniuk et al. 1978; Semeniuk 1980, 1983, 1985; Wells 1981; Johnstone 1990; Cresswell & Semeniuk 2011), with 15 species of mangroves identified along the Kimberley coast (Cresswell & Semeniuk 2011). The greatest species diversity and structural complexity occurs in the high rainfall zone between Cape Londonderry and Walcott Inlet (Masini et al. 2009).

Extensive and diverse intertidal seagrass meadows occur around islands in the western Kimberley, particularly around Sunday Island near the mouth of King Sound (Walker 1995; Walker & Prince 1987). While some seagrasses have been collected from intertidal sites in the central and north Kimberley, these areas were not found to be as species rich and did not support extensive seagrass meadows like those found in the western Kimberley (Masini et al. 2009). Large areas of seasonally-abundant subtidal seagrass communities have also been found along the Dampier Peninsula, from the lower intertidal to depths of approx. 20 m. In this area, subtidal seagrass patches and meadows appear to be well-developed in areas where sediments are relatively fine and stable, such as inter-reefal areas and between/among patches of filter-feeding communities (Masini et al. 2009).

Filter-feeder communities are patchily distributed and vary in spatial extent, diversity and cover, but generally appear to be associated with stable, hard substrates overlain by sand veneers in areas of gently shelving bathymetry. Abundance and diversity appear to be high in some places, however, very little is known about the species represented in these communities (Fry et al. 2008a; Masini et al. 2009). A generally repeating pattern that has been observed around fringing coral reefs is that benthic cover gradually shifts from a predominance of hard corals to filter feeders with increasing water depth. The transition from corals to filter feeders in the Kimberley is suggested to occur at water depths of approximately 10 m, much shallower than in other areas of WA (e.g. Ningaloo Reef). Filter-feeder communities also appear to be well developed down steeply sloping reef fronts, in deep, sandy basins and subtidal reef platforms off islands and mainland shores to depths of approx. 35 m (Masini et al. 2009).

Coral communities are not well developed in the western Kimberley, southwest of Cape Leveque, although there are localised examples off the Dampier Peninsula and at the Lacepede Islands (Fry et al. 2008a; Wilson 1994). North and east of Cape Leveque, however, coral communities become well developed in nearshore environments (with the exception of within King Sound due to high water turbidity). Preliminary surveys indicate that extensive fringing reefs, which support a high abundance and diversity of coral, have developed around many islands and off some mainland shores (Wilson et al. 2011; Masini et al. 2009). Further east, fringing and emergent coral reefs are well developed in the Heyward Island group, around islands within the Bonaparte Archipelago and off mainland shores at Cape Voltaire and Cape Bougainville. Surveys of Maret, Bethier and Montalivet Islands by INPEX recorded 280 species of coral from 55 genera, making the Kimberley the most coral-diverse area in WA (INPEX 2008).

12.1.3.1 Habitat mapping

Due to the remoteness of the Kimberley coast and associated high cost of conducting field work, few benthic habitat studies have been conducted. The main source of habitat information is a collection of studies commissioned by the NDT. The NDT was established by the WA state government to consider issues associated with the location of a multi-user Liquefied Natural Gas (LNG) production hub to service the Browse Basin natural gas fields located off the Kimberley. As part of site selection, the NDT evaluated the relative environmental sensitivities

of 11 potential LNG processing hub sites from Gourdon Bay, just south of Broome, to the Anjo Peninsula in the northwest Kimberley (NDT 2008; Figure 12.6).

Benthic marine habitat studies of the potential site locations were completed by a number of sources, including the Western Australian Marine Science Institution (WAMSI), the Australian Institute of Marine Science (AIMS), CSIRO and the WA Museum. Based on preliminary information, further studies were commissioned at a few of the sites that were determined to be most suitable for the LNG hub location (i.e. James Price Point and the Anjo Peninsula). These studies have provided the majority of benthic marine habitat information for the Kimberley coast.

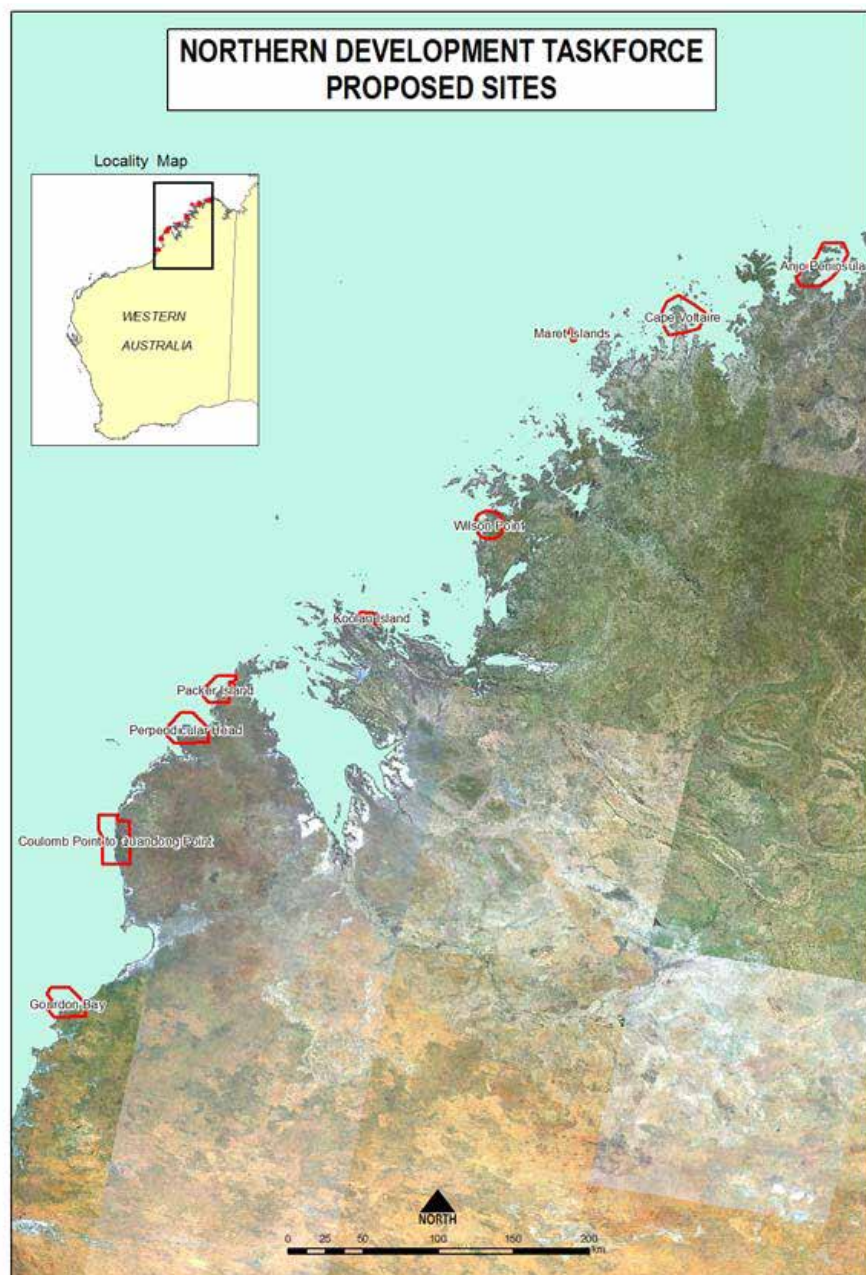


Figure 12.6. Location of sites in the Kimberley Nearshore Ecosystem that were considered by the Northern Development Taskforce as potential sites for a multi-user LNG processing hub. Source: DEC (2008)

12.1.3.1.1 Dampier Peninsula

The Canning region, from the northern edge of Eighty Mile Beach to Cape Leveque, is characterised by a gently shelving bathymetry, long sandy beaches and occasional sandstone headlands. There are no major rivers flowing into the sea along this stretch of coast; however, because of the fine-grained nature of the coastal rocks and the extreme tidal range, the nearshore water is turbid (Wilson 1994).

The coastline from Cape Missiessy to Broome contains a variety of landforms including rocky headlands, intertidal platforms, extensive gravel, sand and mud flats, sand plain cliffs, a variety of mangroves and broad, open beaches. This variety is matched by a high diversity of flora and fauna, particularly in the intertidal and mangrove habitats (Wilson 1994). Offshore, the seafloor gently slopes to the west-north-west. Tidal range is up to 10 m (Wilson 1994).

Mangrove forests and extensive mud flats and sand banks are present in the V-shaped bays towards the northern end of the Dampier Peninsula and in Roebuck Bay (Semeniuk 1983, 1985, 1997; NDT 2008; Masini et al. 2009). Nearshore environments throughout the region are typically macroalgae-dominated reefs with scattered corals, although corals in this area do not form reefs. Filter-feeding communities (e.g. sponges and sea whips) and extensive patches of seagrass are prevalent in deeper waters (NDT 2008).

The southern part of Roebuck Bay consists of linear mangrove forests that are unique on the WA coast. Additionally, there is a very wide intertidal mud flat seaward of the mangroves (Wilson 1994). The mud flats have particular conservation value as a primary feeding site for a variety of migratory sea and shorebirds that make their first landfall and their last point of departure there on their annual migration from and to breeding areas in Siberia and other parts of the northern hemisphere (Wilson 1994). In recognition of this importance for migratory shorebirds, the shores and hinterland of Roebuck Bay have been designated as a Ramsar Wetland of International Importance (Wilson 1994).

Four locations along this coast (Gourdon Bay, Quondong to Coulomb Points, Perpendicular Head and Packer Island) were surveyed as part of the NDT site assessments. During the surveys, the relative abundance of the main functional groups of benthic organisms and substrate types were recorded along 500 m transects at 775 sites using underwater towed video and analysed according to a standardised habitat classification system (Fry et al. 2008a).

Most of the seabed surveyed in the four locations was fine sand, ranging between 50 – 70 % cover within each location. All four locations showed some presence of low to high relief reef structure, predominantly around the shallow waters off the headlands at the two most northern locations (Perpendicular Head and Packer Island). Where there was low relief solid structure present, there were generally diverse patches of filter-feeder communities, such as sponges, sea whips and gorgonians. Soft and hard corals were found at each location, although they were generally low and variable in abundance (Fry et al. 2008a).

Gourdon Bay

Gourdon Bay is located at the southern end of a large sandy embayment that is sheltered to the south by Cape Latouche Treville. The inshore waters of the Bay are relatively protected, and the seabed is comprised mainly of sandy sediments, with small areas of rubble and patchy reefs inshore and near offshore shoals. The sediments in the Bay have extensive areas of algal film and sparse, seasonally-abundant seagrass. Filter-feeder communities occur in deeper waters, but are generally more patchily distributed and are not as diverse as at other locations further north on the Dampier Peninsula (Figure 12.7; Fry et al. 2008a; NDT 2008).

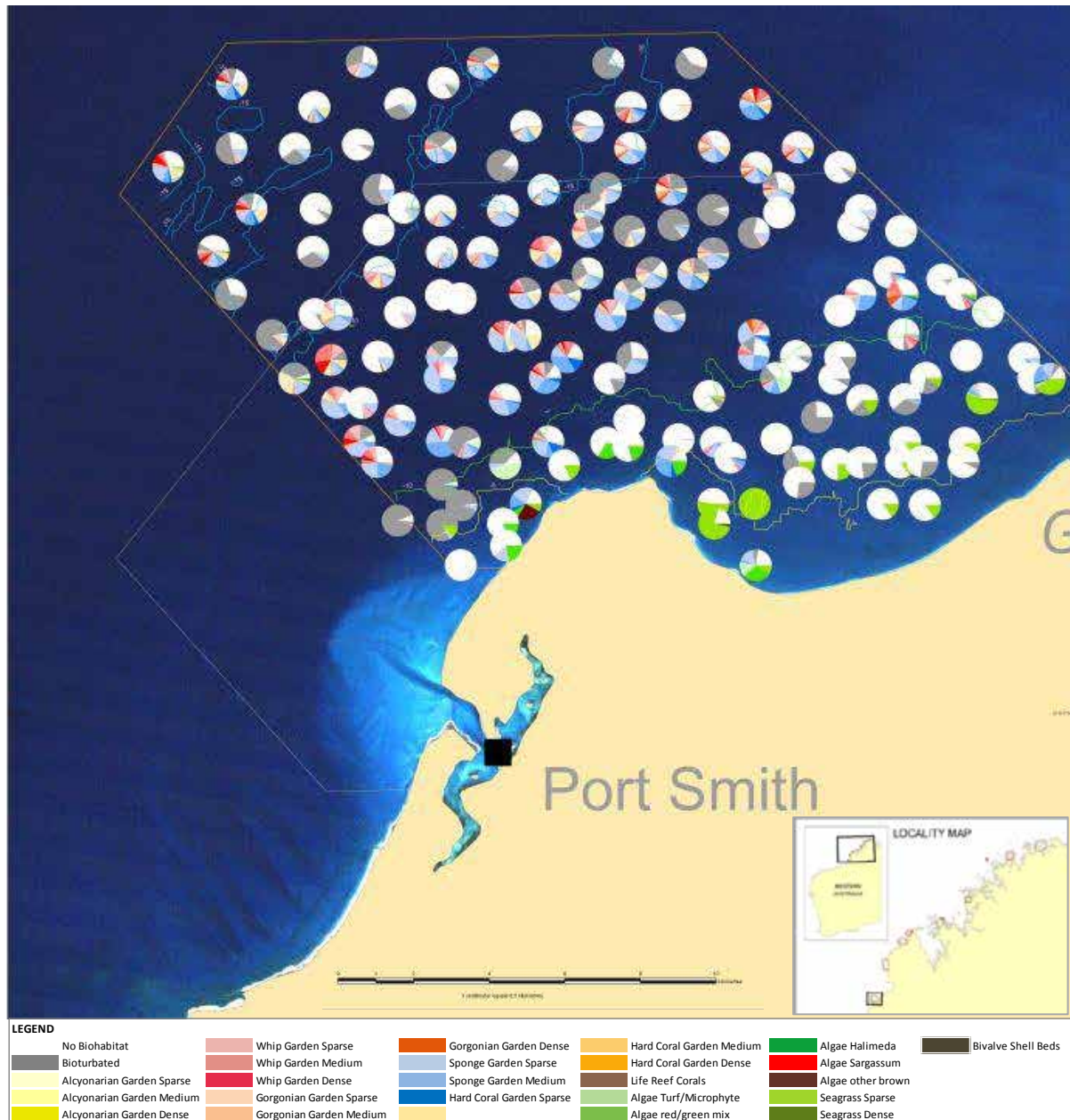


Figure 12.7. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects at Gourdon Bay. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)

Quondong Point to Coulomb Point

Quondong Point is a small rocky point on the sandy west-facing coast of the Dampier Peninsula. Patches of dense seagrass were common in the sheltered areas between inshore reefs, and large areas of seagrass were present in deeper, inshore waters between rock pavements. Corals occurred as isolated colonies or among algae on reefs to about 10 m depth (Figure 12.8; Fry et al. 2008a). James Price Point and Coulomb Point are also on the west-facing coast of the Dampier Peninsula, north of Quondong Point. Significant areas of low-relief reef with dense algal cover were found nearshore, particularly to the north of Coulomb Point. Extensive filter-feeder communities occurred in deeper waters and were particularly diverse and abundant to the north of James Price Point (Figure 12.8; NDT 2008).

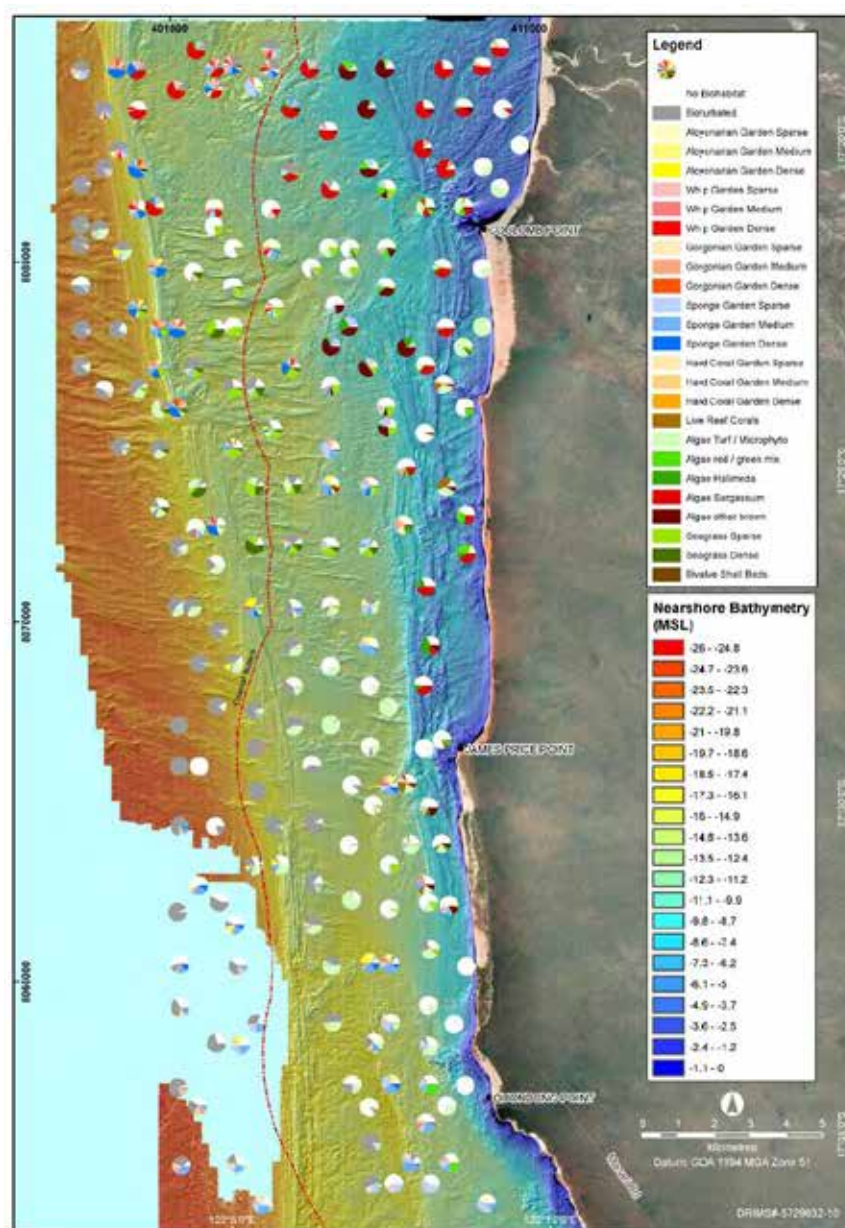


Figure 12.8. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects from Quondong Point to Coulomb Point. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)

Benthic habitats from Quondong Point to Coulomb Point were also mapped as part of a demersal vertebrate assemblage study by Cappo et al. (2010) and Sinclair Knight Merz (2010). Cappo et al. (2010) used Baited Remote Underwater Video Stations (BRUVS) to provide baseline estimates of fish diversity and relative abundance in the James Price Point coastal area in relation to habitat and depth (Cappo et al. 2010). Results showed three major regions of cross-shelf zonation in the study area proximal to each of the coastal points. The cross-shelf zonation off Coulomb Point was comprised of mixed patches of bare ground and beds of marine plants and filter-feeders, with some inshore seagrass. There was a broad band of bare sand extending offshore from James Price Point. Off Quondong Point, there was a sandy coastal bench above a ridge with high epibenthic diversity and abundance along the 20 m depth contour. Marine plants and filter-feeding sponges, gorgonian fans and soft corals were more abundant in the northern and southern parts of the region than directly off James Price Point (Cappo et al. 2010). Sea whips were found mainly in the south along the 20 m depth contour. Seagrasses were not common, but were most abundant in the shallows to the north and south of the region between the 5 m and 20 m depth contours. Macroalgae were widespread, but were most abundant in the north and south in co-occurrence with filter-feeders (see maps in Cappo et al. 2010).

Sinclair Knight Merz (SKM) used habitat data from previous field surveys (e.g. Fry et al. 2008a; SKM 2009a) to develop regression models to define the relationships between the observed habitat distribution and a series of environmental data, principally bathymetry. Towed video surveys of benthic habitats were undertaken in 2009 to validate previously identified habitats (SKM 2009b) and a Laser Airborne Depth Survey (LADS) was used to acquire high resolution bathymetric data.

From the identified relationships, predictive maps were developed showing the distribution of biota, substrate and combined habitat classes. Specifically, the distribution of *Hard Substrate*, *Sediment*, *Hard*, *Coral*, *Soft Coral*, *Algae* (canopy and small algae) and *Sessile Invertebrates* were mapped. Seagrass distribution was mapped separately based on the observed distribution along the survey transects in 2008 and 2009. Validation showed that the model accurately predicted distribution with a high degree of confidence, with correct classification rates ranging from 75 – 96 % (SKM 2010).

A mixed mosaic of biota consisting of hard corals, algae, soft corals, seagrass and sessile invertebrates was found across the survey area (Figure 12.9); however, sediment substrates dominated waters deeper than 10 m. Coral communities in the region were typically sparse (5–10 % coverage) and did not form coral reefs. Hard coral colonies typically co-occurred with other biota types, such as algae, sessile invertebrates and soft coral (Figure 12.9). Foliose (e.g. *Turbinaria*), encrusting and massive species were most commonly found in the nearshore turbid waters. In some instances, seagrass were found growing amongst hard coral communities in inter-reefal sand patches. Algal coverage was extensive in the north of the study area, adjacent to Coulomb Point, with patches of *Sargassum* spp. observed both in the shallows (5–10 m depth) and extending into deeper waters (Figure 12.9). Coverage decreased near James Price Point and to the south of Quondong Point, with most algal cover observed in less than 10 m of water. Sessile invertebrates (including most sponges, sea whips, gorgonians, ascidians, sea pens and soft corals) were the most extensive throughout the area

(Figure 12.9). Modelling predicted the most extensive areas of sessile invertebrates were to the north and in deeper waters to the south of James Price Point, offshore from Quondong Point and Cape Bioleau (SKM 2010).

Based on observations from towed video, seagrass was observed to occur in waters ranging from 4 – 18 m deep (Figure 12.9; SKM 2010). Additionally, unpublished work completed by DEC and AIMS in the James Price Point coastal area in late-2007 found areas of dense seagrass with high biomass. Repeat surveys undertaken in early 2008 at the same locations found no seagrass, while further sampling in mid and late 2008 found seagrass had re-established, with prolific seed production observed in *Halophila* sp., suggesting these communities are seasonally abundant (Masini et al. 2009).

Beagle Bay and Perpendicular Head

Beagle Bay and Trappers Inlet (approx. 3 km north of Beagle Bay) are located between two headlands, making them relatively protected. Both areas contain highly bioturbated sediments and mangrove communities (NDT 2008). Exposure to wave energy is high on the headland and west-facing shoreline, and the offshore waters are characterised by moderate tidal currents and low turbidity. Seagrass patches can be seasonally present in the bays and offshore. Corals generally occur at sparse to moderate density on reefs to about 10 m depth, although areas of moderately dense coral are found inshore from North Head. Further offshore, benthic habitats are generally less diverse than offshore from Perpendicular Head to the north (Figure 12.10; Fry et al. 2008a; NDT 2008).

Perpendicular Head is a prominent rocky headland at the entrance to Pender Bay, about 28 km north of Beagle Bay. Pender Bay is a typical V-shaped bay found along the Canning Coast and contains highly bioturbated sediments and mangrove communities, which are particularly well developed around the creek system in the northern part of the Bay. Dense seagrass patches can be seasonally present in the Bays and are likely to support significant numbers of dugongs. Corals generally occur at sparse to moderate density on reefs to about 10 m depth. Extensive and often diverse filter-feeding communities are common in deeper waters off the headland and waters to the north east (Figure 12.10; Fry et al. 2008a; NDT 2008; Keesing et al. 2011).

Packer Island

Packer Island is located on the northern side of Pender Bay, near the tip of the Dampier Peninsula. It is a barrier island oriented parallel to the shore and linked to the mainland by a narrow isthmus. The west side of the island is exposed to high wave energy, but the east side is very sheltered and consists of two generally sandy, shallow lagoonal embayments. The foreshore is rocky with mangroves backed by tidal flats. High cover seagrass patches are seasonally present in shallow waters on the west side of the island, among algal reefs and pavements. Similar to other areas in the Canning region, there is no biogenic coral reef development, but corals occur at sparse to moderate density on reefs to about 10 m depth. Patches of filter-feeding communities are common on hard and soft substrates in deeper waters and can be very diverse in places (Figure 12.11; NDT 2008).

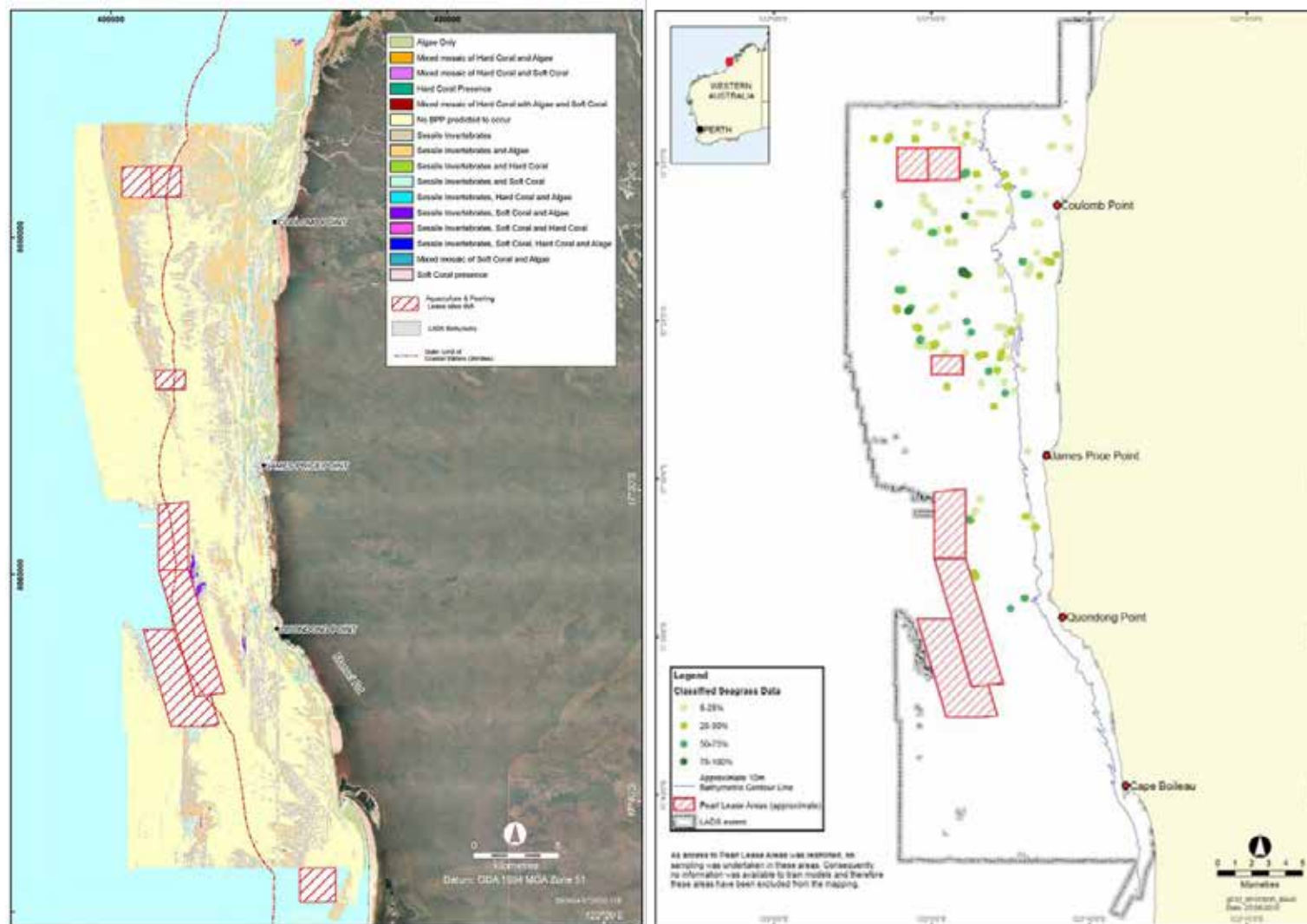


Figure 12.9. Combined benthic habitat map (excluding seagrass) of the James Price Point coastal region (left) and observed distribution of seagrass across the study area based on towed video surveys during June 2008 and November 2009 (right). Source: SKM (2010)

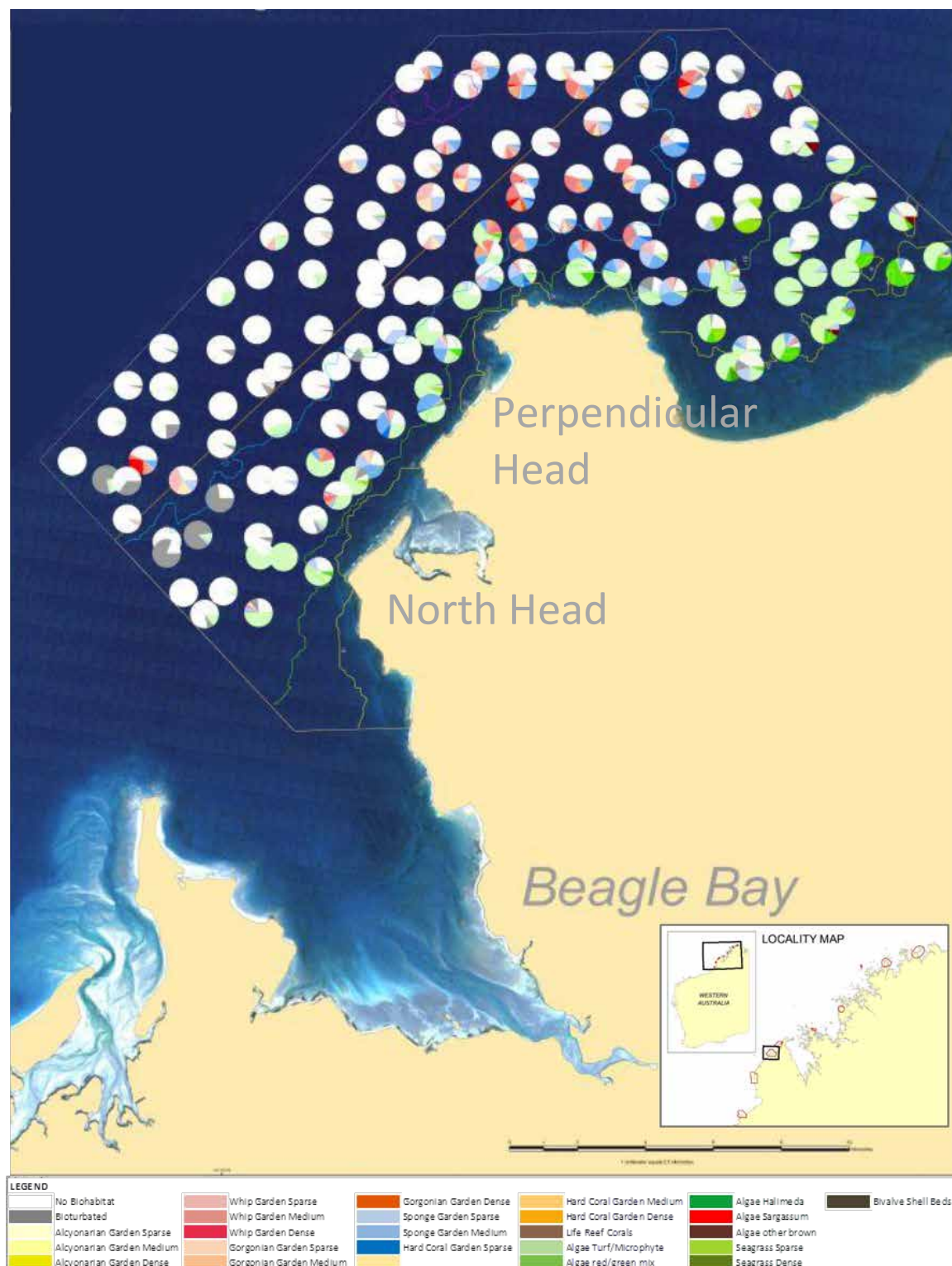


Figure 12.10. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects at North Head and Perpendicular Head. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)

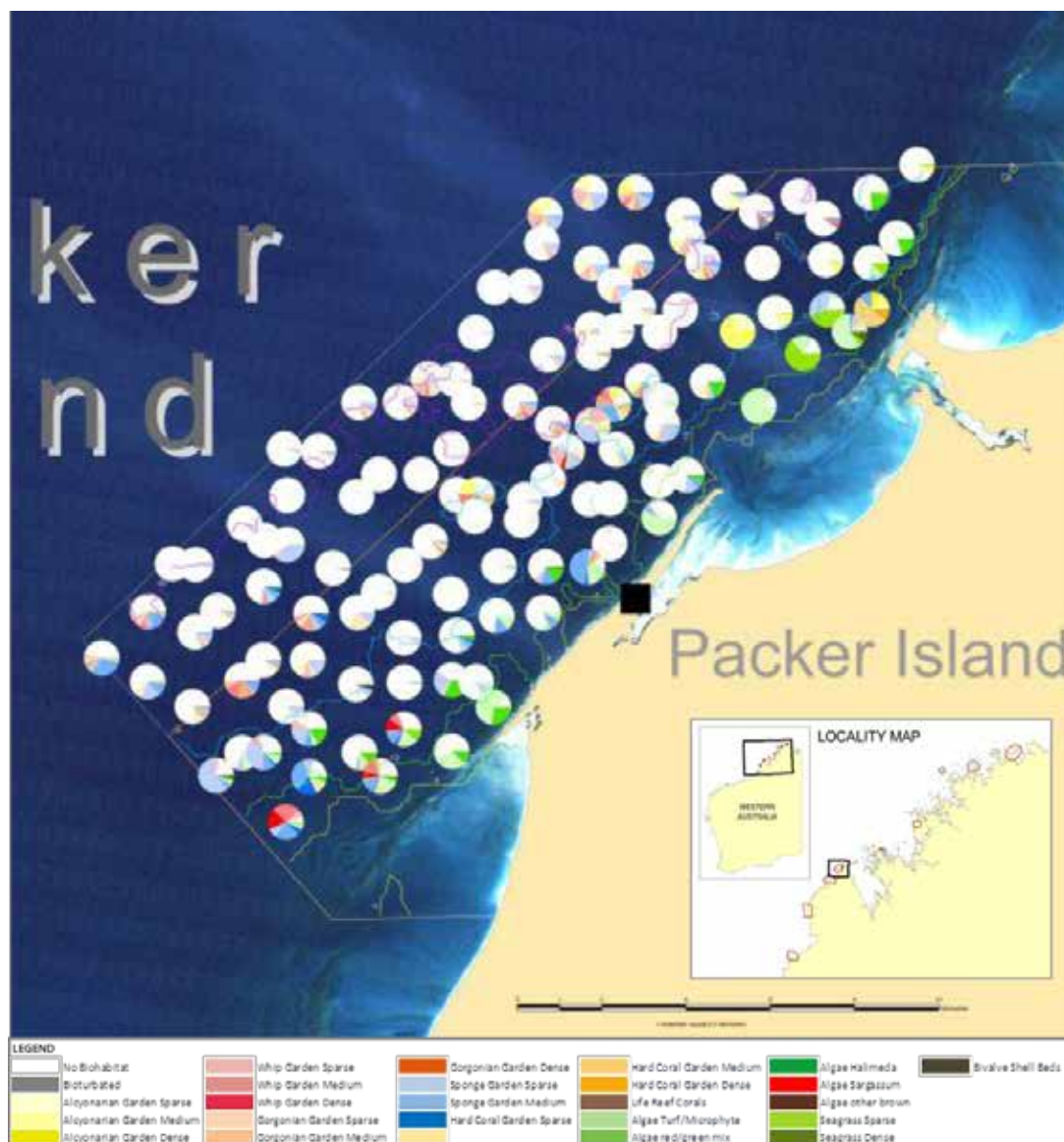


Figure 12.11. Pie chart showing the relative proportions of different benthic habitat types along 500 m towed transects at Packer Island. Note that inshore-most sites are not shown. Source: Fry et al. (2008b)

Lacepede Islands

The Lacepede Islands are located about 18 km off the western coast of the Dampier Peninsula. The group consists of four islands, West, Middle, East and Sandy Islands, and is about 16 km long. The islands are surrounded by a complex of shallow lagoons, intertidal and subtidal rock pavements and sandy cays. The surrounding sea is generally less than 20 m deep (Wilson 1994). The islands were visited by the WA Museum in 1982 and 1987, providing brief habitat descriptions. Mud flats and wide sand flats with algae, but few corals, were noted on the southern side of West Island. Barren, muddy flats were noted on the south side and a barren, stepped intertidal rock platform covered with sparse algal turf was noted on the north side of the island. Together with aerial inspection, these observations revealed that some of the shallow lagoons and outer edges of the reef platforms supported extensive coral reefs. Seagrass beds were also present in some of the lagoons (Wilson 1994).

King Sound

King Sound is a wide, open gulf with a low relief shoreline and features of a seasonal estuary (Semeniuk 1985). Waters within the sound are highly turbid, and tidal amplitudes reach 11 m, making them among the highest in the world. The shores of King Sound have extensive mangroves and associated intertidal and supratidal flats (Masini et al. 2009). Benthic habitats are likely to be hard bottomed with some mud but very little sand (DEWHA 2008).

12.1.3.1.2 Central Kimberley

East of King Sound, the Kimberley coast becomes more remote. There are a variety of coastal and marine habitats, including mangroves, mud flats and sand banks, seagrasses, filter-feeder communities and coral reefs, many of which are regarded as highly diverse (CoA 2007).

Camden Sound

Information on the marine habitats of Camden Sound is provided in the management plan for the new Lalang-garram / Camden Sound Marine Park (DPaW 2013). A large portion of the area consists of intertidal and subtidal bare rock as an extension of the rocky mainland. These rocky areas provide substrate for a variety of marine organisms including sponges and corals (DPaW 2013). Sponge-dominated areas have been recorded on and below reef edges between the mainland and small nearshore islands (Blakeway 1997). Various types of macroalgae also occur on rock platforms intermingled with coral and sponge (DPaW 2013).

The Montgomery Islands lie in the centre of the reef platform and have extensive mangrove forests. The edges of the reef below low water mark and the surrounding waters host diverse marine communities, while deeper subtidal habitats are likely to be dominated by sand and mud. The reef platform drains continually on the low tide, but rarely empties, resulting in a shallow lagoon lying between the rim and central islands (DPaW 2013; Wilson and Blake 2011). Corals occur in the subtidal areas around the Montgomery Islands reef and in the many rock pools on the platform that are shaded by algae or rock ledges. A large reef also lies between Jungulu and Augustus Islands that has extensive coral on its edges (DPaW 2013). An initial survey of the reef by AIMS in 2009 indicated moderate coral diversity and cover, particularly around the outer edges of the reef, with few corals across the intertidal reef top (which is dominated by algae and sand). A large, fringing, intertidal reef also occurs at the Champagney Islands across a variable depth range on both the seaward and lee side of the islands (DPaW 2013).

Wilson Point is located within a relatively sheltered and deep embayment in Camden Sound. The coast is predominantly rocky, with steep slopes and few sandy beaches. There are small patches of mangroves at the base of creek lines, as well as in Deception Bay to the south and Kuri Bay to the northeast. The steep bathymetry and range of exposure to waves and tidal currents provide a range of habitats that support a high diversity of marine life. Coral reef formations occur inside the bay, with extensive and well-developed staghorn corals thickets in places. Tabular and massive forms dominated in more exposed areas, and

diverse filter-feeding communities and soft-sediment communities are common in deeper water (NDT 2008).

Admiralty Gulf to Anjo Peninsula

From Admiralty Gulf north to the Anjo Peninsula, the coast is extremely complex, with wide bays, narrow inlets and many islands and offshore banks. Along the shore, rocky headlands alternate with sandy bays, some of which have fringing mangroves. There are extensive tidal and subtidal sand and mud banks in the bays, which may support seagrass beds. There are many rocky islands along the coast. Three major rivers enter the sea in this region, the King Edward, Lawley and Mitchell, each with a small estuary and associated mangrove system (Wilson 1994).

The Anjo Peninsula forms the western boundary of Napier Broome Bay. The northwestern side of the Peninsula faces the Eclipse Archipelago and Vansittart Bay. There are several islands, unnamed rocky outcrops and reefs off the eastern and northern coasts of the Anjo Peninsula. The eastern side of the peninsula is relatively indented and sheltered from swell by offshore banks and several islands. This area experiences one of the lowest tidal ranges in the Kimberley Nearshore Ecosystem (KNE) (3 m), although tidal currents can still be significant. The coastline of the peninsula is characterised by narrow bands of fringing mangroves, interspersed with sandy beaches and rocky shores. Patches of dense mangroves are associated with tidal creek mouths and along some of the islands (NDT 2008).

A survey of the marine benthic habitats in the vicinity of the Anjo Peninsula has been conducted by DEC (2008). Using video footage, benthic habitats around the Anjo Peninsula were described and broadly classified into eight groups which were used to produce a preliminary benthic habitat map (Figure 12.12). The western side of the peninsula was dominated by reef substrates, although they generally did not support abundant live hard coral. In areas where dead coral and coral rubble were the predominant substrates, macroalgae and turf algal communities occurred. Macroalgae cover on reefs varied from occasional individual plants to dense cover of canopy-forming species (e.g. *Sargassum*) and communities of mixed macroalgal (e.g. *Padina*, *Lobophora*, *Turbinaria* and *Dictyota* spp.) and turf species (DEC 2008).

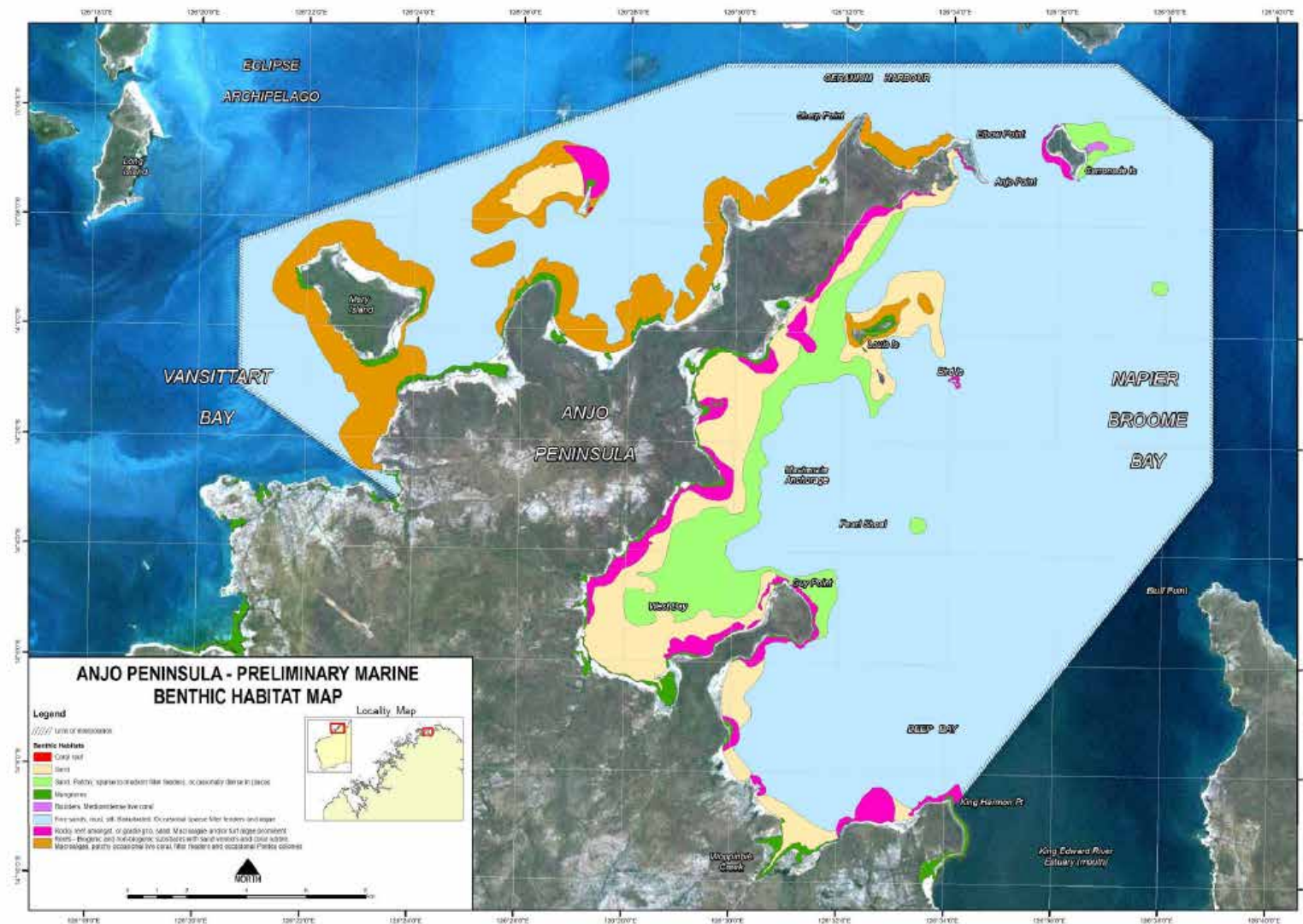
The north-western coast of the Anjo Peninsula also had sections of sandy beach that were occasionally interrupted by tidal creek mouths, mangrove stands and low sandstone rock headlands that extended out into the shallows. The subtidal sandstone rocks were generally covered with macroalgal communities similar to those found in Napier Broome Bay but without the tall *Sargassum* canopy. Much of the shore line was also paralleled by a largely dead, fringing coral reef formation. This reef formation was shallow (1 – 3 m), with an outer seaward edge located between approximately 400 m to 1.6 km offshore. The most prominent benthic biota on the reef was macroalgae, but sparse hard coral colonies and filter feeders were also observed. Inshore, the area graded to a lagoon of mainly rubble and sand (Figure 12.12; DEC 2008).

Napier Broome Bay

Mangrove communities are common along the shores of Napier Broome Bay (Figure 12.12), including in tidal creek mouths and on elevated intertidal rocky platforms, such as around Louis Island. Extended sections of coast on the western side of the Bay are fringed by a narrow mangrove forest, which is occasionally interrupted by sandy beaches, rocky coastline and mangrove-lined tidal creeks. There are extensive stands of mangroves at the southern end of West Bay and also southeast of Guy Point where Woppinbie Creek and King Edward River discharge into Deep Bay (DEC 2008).

Rocky reefs in the Bay support mixed macroalgal and invertebrate communities (Figure 12.12). These reefs have a low number and diversity of coral colonies present, but corals tend to increase towards the tip of the Anjo Peninsula and offshore. Abundant live hard coral occurs in places on biogenic and sandstone substrates, but these communities appear to be relatively restricted in their extent and distribution off the north and west coasts of the peninsula (DEC 2008). Given that dugongs are known to occur in southern portions of Napier Broome Bay (sometimes in considerable numbers), it is likely that seagrass would occur near Woppinbie Creek; however, no seagrass was observed during the 2008 survey, possibly because the time of the year when the survey was conducted may have been coincident with a period of natural seagrass senescence. Within the Bay, there are also broad areas of fine, bioturbated sediments and sandy sediments that supported patchy to medium density communities of filter-feeders (DEC 2008).

At the eastern-most site surveyed in Napier Broome Bay, fine sands supported very dense patches of soft coral communities (Figure 12.12). These communities were distributed among areas of mostly bare fine sediments. The patches of soft corals were generally only about 5 – 10 m across and may indicate the presence of hard substrate under the veneer of fine sediment. Fine sediment habitats that supported variable densities of filter feeders appeared to extend west from Napier Broome Bay and into the deeper waters of Geranium Harbour (Figure 12.12; DEC 2008).



Cape Londonderry

Cape Londonderry is the most northerly point of the WA mainland and is located at the top of a wide peninsula forming the eastern side of Napier Broome Bay. The northern and eastern shores of the peninsula are rugged with colourful cliffs up to 50 m high and many small, irregular bays with small sandy beaches between rocky headlands. Little is known of the marine environment in this area. Most of the information about the area relies on aerial photographs and notes made by the WA Museum Kimberley Survey of 1991 (Wilson 1994).

There are two major estuaries, one at the mouth of the King George River and the other at the mouth of the Drysdale River, that have significant mangrove development (Wilson 1994). There is an area of wide shallows on the northern side of the peninsula between Cape Londonderry and Cape Talbot, which appears to be fringed with reef and supports extensive seagrass beds (Wilson 1994). A similar reef area can be found surrounding Lesueur Island, which has been described as reef with live coral and limestone, with a small drop off to rubble and bommies of live coral by (Morgan 1992).

Joseph Bonaparte Gulf

The Joseph Bonaparte Gulf is an extensive, shallow (generally < 100 m) gulf east of Cape Londonderry. The continental shelf in the Joseph Bonaparte Gulf is the widest in Australia, extending up to 400 km from the shore (Przeslowski et al. 2011). The western boundary of the Gulf joins with the Indian Ocean, while the northern boundary joins with the Timor Sea. The inshore area is characterised by terrestrial inputs of freshwater, sediments and detritus, which are generally restricted to a distinct coastal boundary layer (Lees 1992; Brewer et al. 2007).

The majority of the seafloor is smooth bottom overlain by soft, muddy substrates (CoA 2007). The soft bottom habitats are likely to support mobile invertebrate communities, such as prawns and crabs. Assemblages of filter feeders, such as ascidians and byozoans, are also likely to occur (CoA 2007). Dugongs can be found throughout the Gulf and are associated with seagrass communities in the nearshore waters < 5 m depth (CoA 2007). The epibenthos over most of the Gulf is sparse (URS 2009; Woodside Energy Ltd 2001), although some scattered islands, reefs and other features in the inner Gulf may support corals, macroalgae and seagrass (e.g. King Shoal, Medusa Banks and Howland Shoals; RPS 2009). The occurrence of these communities, however, is much sparser than the dense assemblages of sessile invertebrates recorded offshore in the far northwestern Gulf (URS 2009).

Cambridge Gulf

The Cambridge Gulf is broadly open seasonal estuary located at the head of the wide Joseph Bonaparte Gulf. The Cambridge Gulf is the open estuary of the Ord, King, Pentecost, Durack and Forrest Rivers. Runoff is low, between 50 and 250 mm of annual rainfall, although these large rivers provide seasonal inflows (IMCRA 1998). Waters of the Cambridge Gulf are generally turbid due to tides (diurnal flows with approximately 6 – 7 m of variation) and a predominance of fine sediment; however, further offshore, within the Joseph Bonaparte Gulf,

the waters become clearer. Rainfall is seasonal in this area (summer) and ranges from 700 mm to 1800 mm (IMCRA 1998).

The eastern side of Cambridge Gulf is low relief, dominated by the wide delta of the Ord River and has extensive mangroves (18 species recorded; IMCRA 1998). The mangroves of the north east corner of the Gulf have an area of over 500 km² and comprise a complex, dendritic system of drainage channels leading to a series of wide tidal rivers known as the False Mouths of the Ord, which are protected from the open sea by the Cape Domett Peninsula (Wilson 1994). The western side of Cambridge Gulf is relatively high and has narrow fringing mangroves in small bays between rocky headlands. From Cape Dussejour, the headland at the western entrance of the Gulf, north-westwards to Cape Londonderry, the coast has high relief with rocky shores exposed to the prevailing easterly wind. There are only a few small mangroves in the bays along this coastline (Wilson 1994).

12.2 Marine Protected Areas

There are a number of marine protected areas in the NCB that have been proclaimed under the *Conservation and Land Management Act 1984* (CALM), including the Montebello and Barrow Islands Marine Conservation Reserves, the Rowley Shoals Marine Park, Eighty Mile Beach Marine Park¹² and the Lalang-garram / Camden Sound Marine Park⁵, as well as total fishing closures (under Section 43 of the FRMA) at Point Samson and the Kunmunya and Samson II wreck at Delambre Reef. There are also four proposed State-managed marine parks in the NCB at Dampier Archipelago, Roebuck Bay, Horizontal Waterfalls and North Kimberley (Figure 12.13).

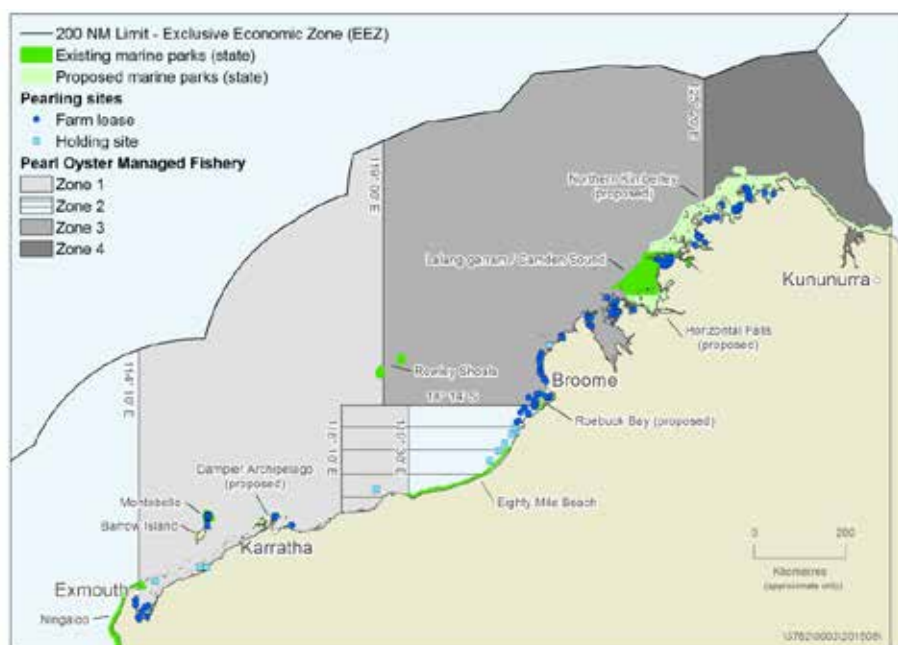


Figure 12.13. Existing and proposed State marine parks that overlap with the WA pearl oyster fishery area

¹² Note, the zoning scheme is not yet in place for the Eighty Mile Beach or Lalang-garram / Camden Sound Marine Parks.

The Department has been an active participant in the marine conservation planning process in the Kimberley region, and is responsible for the joint management of the recently established Lalang-garram / Camden Sound Marine Park. The Department has recently received funding to establish baseline and ongoing monitoring and research to underpin ecosystem management of this area. There is considerable interest in developing further marine protected areas within the Kimberley region, and the Department continues to work closely with relevant agencies and stakeholders to develop strategies to minimise environmental effects, including the Kimberley Science and Conservation Strategy with DPaW.

There are three Commonwealth marine reserves in place in the NCB at Mermaid Reef, Ashmore Reef, and Cartier Island. Following a Marine Bioregional Planning process for Commonwealth waters between Shark Bay and the Northern Territory border, the Federal Minister has also recently announced a proposed reserve network¹³ for the North West region, which will include marine reserves at Ashmore and Cartier Islands, the Montebello Islands, Dampier Archipelago, Eighty Mile Beach, Roebuck Bay, the Argo-Rowley Terrace and the western Kimberley Coast (Figure 12.14).

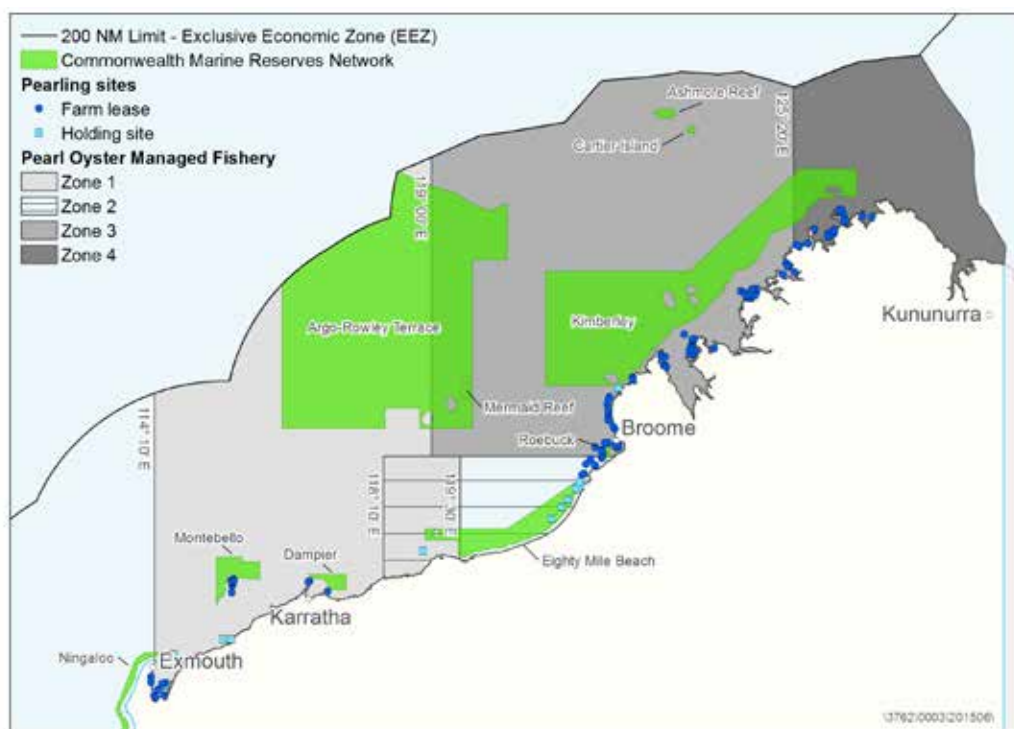


Figure 12.14. Proposed Commonwealth marine reserve network in the north-west region of WA and overlap with the WA pearl oyster fishery zones

12.2.1 Marine Park Zoning

The implementation of an appropriate zoning scheme is an important strategy for both the conservation of marine biodiversity and the management of human use in marine parks. Marine park zoning assists in separating conflicting uses and provides for specific activities such as for commercial and recreational activities, scientific study and nature appreciation.

¹³ See <http://www.environment.gov.au/topics/marine/marine-reserves/north-west> for more information on Commonwealth Marine Reserves in the North West region.

The zoning scheme also offers the opportunity to increase recognition and protection of culturally significant areas.

Section 13B of the CALM requires marine parks to be zoned as one or a combination of specific management zones (sanctuary, recreation, special purpose or general use zones), which are formally established as classified areas under Section 62 of the CALM Act. An overview of the zoning restrictions for marine parks in WA is provided below:

- Sanctuary zones: managed solely for nature conservation and low impact recreation and tourism. Passive recreational activities that do not compromise the ecological values are permitted but extractive activities are not;
- Special purpose zones: managed for a particular conservation purpose and / or priority use, such as protection of cultural heritage, seasonal events (e.g. whale breeding) or a particular type of activity, such as pearling. Uses that are not compatible with the specified conservation purpose are not permitted;
- Recreational zones: provide for conservation and compatible recreational activities. Commercial fishing, pearling, aquaculture and petroleum development is not permitted; and
- General use zones: activities (including pearling) may be permitted where it is considered they do not compromise the cultural and ecological values of the marine park. In some areas, proposals for activities must be assessed and approved by relevant agencies.

12.2.1.1 Special Purpose Zones — Pearling

Both the CALM and the PA provide for pearling in marine parks and reserves. The Acts specify that pearling is permitted in a marine park general use zone and special purpose zone, if it is compatible with the specified purpose of the zone. Farm leases that existed prior to the establishment of a marine park have a right of renewal and will not be displaced by the creation of a marine park. New proposals for farm leases will be assessed on a case-by-case basis by the Department in liaison with DPaW, DoTE, the Marine Parks and Reserves Authority (MPRA) and other stakeholders as required.

Montebello Islands Marine Park

Approximately 550 hectares within the Montebello Islands Marine Park are zoned as special purpose areas for pearling (accounting for ~ 1 % of the Marine Park area). At the time of gazettal, these zones were established for Morgan and Company Pty Ltd.'s existing pearling leases, as well as a quarantine site, to allow pearling to be the priority use of these waters. Other pearl leases held by Morgan and Company Pty Ltd. at the time were zoned for general use. At the time of gazettal, pearling leases held by Fantome Pearls Pty Ltd were within the unzoned area of the marine management area (Figure 12.15 and Figure 12.16; DEC 2007).

Lalang-garram / Camden Sound Marine Park

A special purpose zone (pearling) in the Augustus Island area has been established in recognition of WA's longest operating and largest cluster of pearling operations at Kuri Bay. The zone, which also provides for conservation outcomes, covers about 56 200 hectares (approximately 8 %) of the marine park. In 2013, there were 13 pearl oyster farm leases operating within the marine park (Figure 12.17; DPaW 2013).

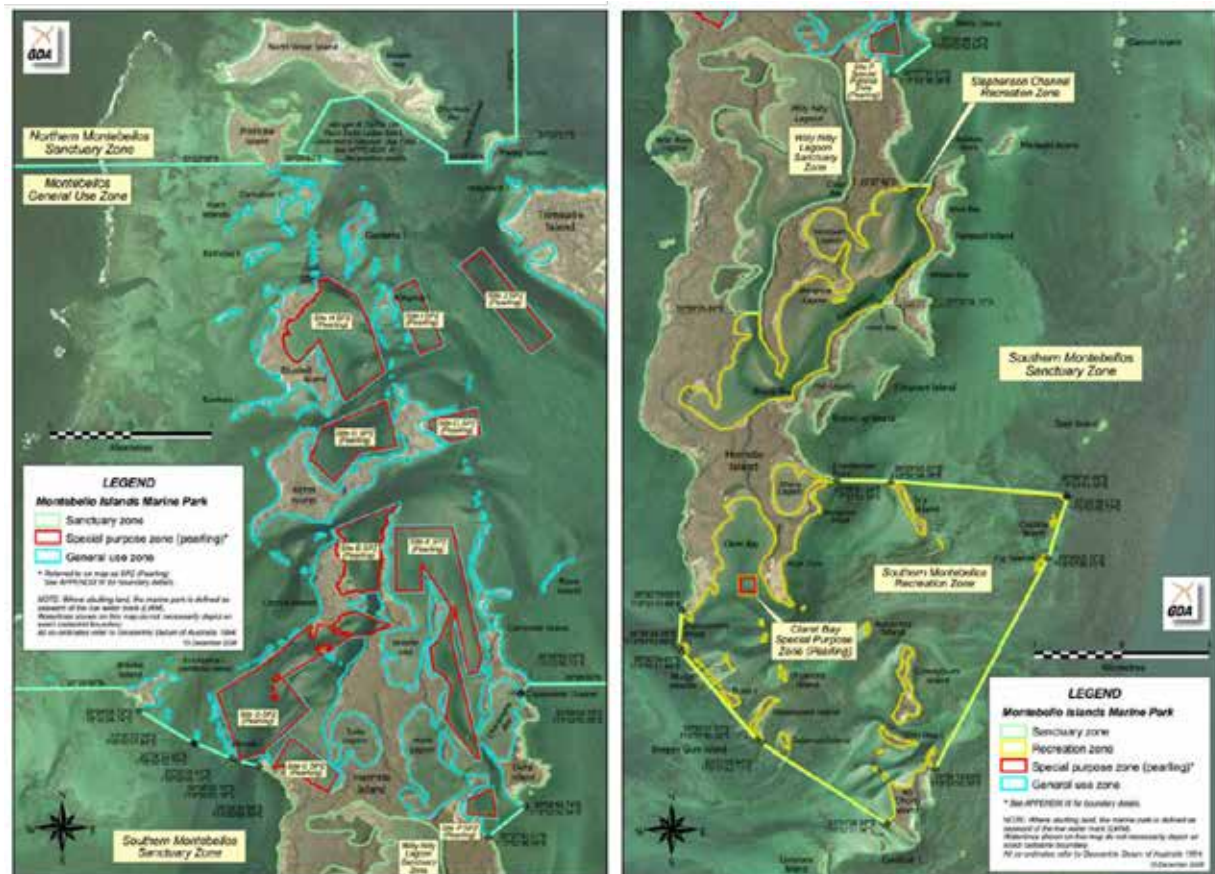


Figure 12.15. Detail of zoning scheme for Montebello Islands Marine Park north (left) and south (right). Source: DEC 2007

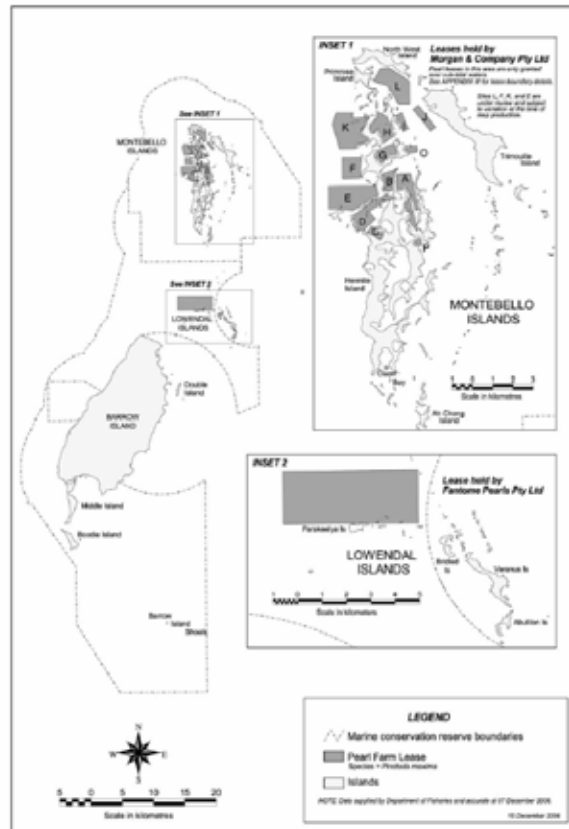


Figure 12.16. Pearling leases of the Montebello / Lowendal / Barrow Islands at time of Marine Park zoning gazettal. Source: DEC 2007

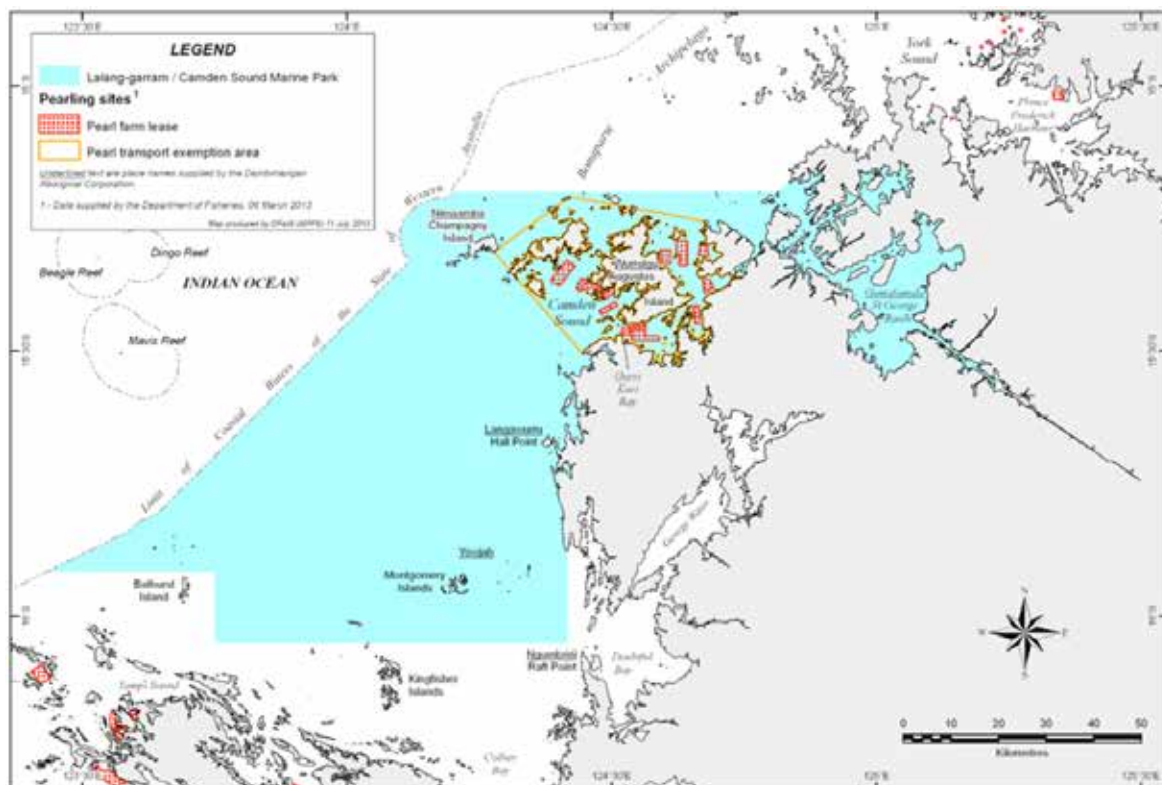


Figure 12.17. Pearling sites within and adjacent to the Lalang-garram / Camden Sound Marine Park in 2013. Source: DPaw 2013

12.3 Pearling industry impacts

12.3.1 Wild collection

The seabed in pearl oyster fishing grounds is typically a flat basement rock with very little relief. Fine sediment accumulates on this rock to a depth of a few millimetres, obscuring the underlying rock surface. A variety of organisms attach to the rock surface and provide a vertical relief of up to one metre off the bottom (Fletcher et al. 2006; Daume et al. 2009). The pearling industry has recognised a variety of bottom types within the pearl oyster fishing grounds and has developed names for them over the years, such as ‘stone’, ‘potato’ and ‘garden’ bottom. While ‘potato’ and ‘garden’ bottom areas dominate the fishing grounds, several other bottom types are also recognised, such as ‘collar’, ‘asparagus’ and ‘magic carpet’. All habitats share a common feature of being located over rock substrate and comprise a wide variety of invertebrates.

A ‘stone’ bottom is comprised of stone and coral rubble of various sizes covered by coralline red algae and rounded by the rolling effect from tides and currents. A mixture of whips corals, sea fans, sponges and coloured corals can be attached (Daume et al. 2009). ‘Potato’ bottom areas are dominated by low, round, densely-spaced ascidian species, which live attached to the bottom. The seafloor has a flat plate of underlying rock, overlain with a few millimetres of sand. In areas of heavy ‘potato’ bottom, the ascidians are almost completely dominant. Sponges are the next main group, with a large variety of vase-shaped, basket and massive sponges up to 0.5 m high interspersed with smaller sponges only a few centimetres high. Total diversity is low, with very few corals present. Bare sand patches can be interspersed between areas of potato bottom, and faunal density rapidly decreases in areas where sediment is 2 – 3 cm deep (Fletcher et al. 2006; Figure 12.18a). The ‘garden’ bottom is a very diverse assemblage dominated by hydroids. The hydroids grow rapidly up to one metre in height and quickly become encrusted with a variety of organisms, some of which are very colourful. Distance between hydroids is variable, but on average, they grow about one metre apart. Other than hydroids, a variety of sponges are present on the bottom. Ascidians are also present but are a larger species than that found on potato bottom. Other fauna present include soft corals, sea pens and crinoids. No hard corals are generally found (Fletcher et al. 2006; Figure 12.18b).

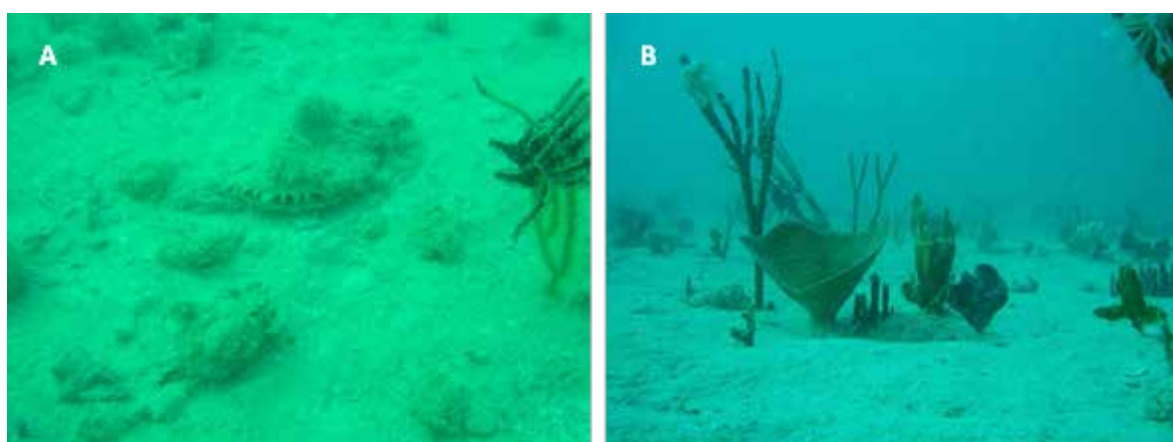


Figure 12.18. Example of the two main habitat types encountered by the WA pearling industry: (a) ‘potato’ bottom (with pearl oyster) and (b) ‘garden’ bottom.

The main habitats used by the pearling industry are ‘garden’ and ‘potato’ bottom. Pearling activities do not generally occur in ecologically sensitive areas, such as seagrasses, coral reefs and mangroves (Fletcher et al. 2006). While pearl oysters occur in these areas, their densities are insufficient to allow them to be commercially fished (Enzer Marine Environmental Consulting 1998).

Fishing for pearl oysters generally involves the extension of booms outwards from each side of the vessel, with a number of weighted ropes hung vertically from each boom to a height of approximately one to two metres above the seabed. Since water clarity is paramount to divers being able to capture the pearl oysters efficiently (i.e. identify the appropriate sized oysters), significant effort is put in place to ensure the weights do not strike the sea floor. The divers will signal to the vessel to raise the weights according to the sea floor height, thus preventing the weights from striking the bottom. Not only does this practice prevent damage to the bottom, but it also allows the diver to efficiently fish for pearl oysters (Fletcher et al. 2006).

Commercial fishing can only occur where the pearl oysters are at appropriate depths to accommodate safe diving and at economically viable concentrations. There are few areas that meet these conditions; therefore, many areas within the fishing grounds remain unfished. Fishers mark most suitable areas for fishing within each zone within a GPS, although new areas are explored and fished each year as quantities and the ability to access fishing areas varies from year to year (Fletcher et al. 2006).

12.3.2 Dump and holding sites

Once pearl oysters have been collected, cleaned, and placed in tagged panels they are stored on the sea floor on dump and/or holding sites until needed. Benthic habitats in these areas are generally similar to those on the fishing grounds, e.g. ‘garden’ or ‘potato’ bottom, and the seafloors in the area must be sufficiently hard that the panels do not sink into the mud.

Dump site locations are reported to compliance staff in Broome, are used on a temporary basis only and are marked with surface buoys so they can be relocated as required.

In 2013 and 2014, 105 km² were used as holding sites in WA; 95 km² were used in 2015. All holding sites are located in depths of 0 – 30 metres.

Holding sites are generally considered to be low impact because:

- Approval for a holding site does not restrict or preclude access by other legitimate users;
- Holding sites are used on a temporary basis only and do not result in the grant of any lease rights associated with a particular site;
- Any bottom structures are positioned to minimise any potential damage to corals and seagrasses beds (e.g. apparatus is not to be placed on top of hard reef platforms);
- Under the *Pearling Act 1990*, all pearl oysters must be removed from the holding sites by 31 December each year (unless otherwise specified). Pearling companies must also remove all apparatus from the site (as per MPG No. 8; DoF 1998).

The environmental effects of a holding site off 80 Mile Beach were assessed by Enzer Marine Environmental Consulting (1998). Within the surveyed area (a 300 m transect within the holding site), the rope between panels went through several sea fans and alongside some sponges, causing minor damage but no significant problems. One panel was found leaning against a coral (*Turbinaria*), but the coral was not damaged. After the panels have been dropped down from the surface, divers place them individually into proper position on the seafloor so the pearl oysters can feed. The divers also make sure the rope and panels are not caught on corals, etc., because chafing on hard surfaces would cut the pearl oysters free or break the rope when it is being pulled up to a boat on retrieval (IRC Environment 2002).

12.3.3 Pearl oyster farm leases

- Pearl oyster farm leases (farm leases) are located throughout the northwest region, with a number of farm leases in Exmouth Gulf, Barrow and the Montebello Islands, the Dampier Peninsula, King Sound and the northern Kimberley coast (see Figure 2.3). The area of seabed leased for grow out and/or cultivation of pearl oyster is matched to the area required to cultivate the quota units allocated and/or pearl oyster stock holdings to each company. Therefore, if a company applies for a new farm lease, the company's total leased areas need to be within this requirement. (MPG No. 17; DoF 2001).

The majority of farm leases are located in less than 30 m depth. In 2013, 675 km² were used as farm lease areas in WA. This was reduced to 655 km² and 650 km² in 2014 and 2015, respectively. The total area of shallow seabed (< 20 m depth) from Exmouth Gulf to the NT border leased over the last five years (2011 – 2015) is ~ 780 km².

Since 1998, there has been a formal process in place for the assessment of applications for new farm leases in WA (see MPG No. 8). This procedure requires that all new applications for farm leases are assessed to determine their potential impacts on the marine environment, including habitat impacts. Pearl oyster aquaculture differs from other bivalve aquacultures due to differences in stocking densities, filtering and biodeposition rates, removal practices of biofouling organisms, other husbandry practices and farm locations (Jelbart 2011). As no chemicals or feed are used in the pearl oyster cultivation process, the primary potential impact from the pearling industry is considered to be the deposition of feces and pseudofeces from the cultured pearl oysters and fallout of debris from the longlines that suspend the pearl oysters (Gifford et al. 2004; O'Connor et al. 2003; Yokoyama 2002). Pearl oysters produce biodeposits in the form of feces and pseudofecal pellets as a waste product. These biodeposits are thought to be similar in composition to the natural sediments because they are derived from phytoplankton and suspended particles (Grant et al. 1995); however, these biodeposits and shell debris can accumulate in the sediments below the pearl oyster longlines and potentially lead to localised organic enrichment and eutrophication. This process can be intensified through the cleaning of biofouling organisms from the pearl oyster shells, which also accumulate beneath the farm lease.

On the farm leases, pearl oysters are cleaned approximately every 4 weeks. During the cleaning process the lines are removed from the water, and one crew member manually

cleans the lines and floats. Panels are placed into a machine and cleaned with high pressure seawater. No chemicals are used in the process. When the panels emerge from the machine, encrusting organisms on the shells are removed by hand and the panels, floats and lines returned to the water. Even after cleaning, there is still some material adhering to the pearl oyster shell; this helps prevent the settlement of barnacles (IRC Environment 2002). Material removed from the pearl oyster is largely algae, with a variety of other organisms such as sponges, molluscs, crustaceans, polychaetes and ascidians. Due to the regularity of the cleaning regime relatively few barnacles were seen. The great majority of the material breaks down very rapidly, with shell material from molluscs, barnacles etc. settles to the bottom. The amount of calcareous material removed from pearl oyster shells during cleaning varies considerable both spatially and temporally, but is never large. The lines are worked on site, so the material returned to the sea is widely dispersed over the farm lease. In addition, material disperses further as it settles to the bottom in 15 to 30 m of water. It is very unlikely that there is any accumulation of material on the bottom (IRC Environment 2002).

Potential interactions between pearl oyster farm leases and marine habitats, particularly seabed communities, have been studied at several locations around Asia and Australia. A brief summary of these studies is provided below:

- Beagle Bay, WA — survey of the seabed beneath longlines conducted by the WA museum and found no measurable impact (Western Australian Museum 1997);
- Montebellos Islands, WA — sampling program inside and outside a pearl *P. maxima* lease found no impact of pearl farms on abundance and diversity of the benthic macrofauna community (Prince 1999);
- Gokasho Bay, Japan — compared impacts of raft pearl farming (*P. martensii*) and fish cages by measuring macrobenthic fauna and sediment nutrient loads (carbon, nitrogen, sulphur and dissolved oxygen) and found that fish farming created a large impact on macrobenthic fauna and sediments, whereas the pearl farming caused fewer effects. The community structure at the pearl farm site was similar to that of the control site, although there were lower densities and species diversity at the farm site (Yokoyama 2002).
- Port Stephens, NSW — environmental impacts of pearl farming (*P. imbricata*) investigated using sediment samples with results indicating no significant changes in the sediments underneath the experimental farm over time relative to the control sites (O'Connor et al. 2003) and an environmental impact assessment, which found no impact of a pearl longline farm on sediment chemistry (Gifford 2004);

Within the Kimberley region, the impacts of pearl farming on benthic assemblages and the physico-chemistry of sediments have been investigated in a comprehensive study conducted over multiple years (McCallum & Prince 2009; Jelbart et al. 2011). This study investigated the influence of *P. maxima* culture on the benthic assemblages and sediment physico-chemistry of the Kimberley coast at three pearl oyster farm leases: Cygnet Bay, Port George and Vansittart Bay (Figure 12.19). Each of these farm leases had been in operation for over

the years at the time of sampling and was located in separate bays along the coast (over 100s of km apart). Within each bay, the abundance and composition of the benthos under the farm lease was compared to four reference locations situated at least 1 km from the farm lease. Within each location, there were three study sites spaces 50 m apart (similar to the spacing of pearl longlines). Sediment core samples were taken to measure physico-chemical variables (redox potential, nutrients loads and total organic matter) while grab samples collected the benthic macrofauna (> 1 mm in size). There were ten sampling occasions over two years (October 2006 to November 2008).

At all three farm leases there was no indication of eutrophication (nutrient enrichment), nor was there evidence of any consistent change in the total number of benthic macrofauna taxa or individuals within soft sediments that may be directly attributed to pearl oyster longline compared to reference locations (Figure 12.20). There was considerable natural variability of the benthic macrofauna among all locations but especially among the reference locations (Figure 12.21), indicating the diversity of taxa and their relative abundances within the sediments underlying the farm leases fell within the range of natural variability found at these spatial scales (Jelbart et al. 2011).

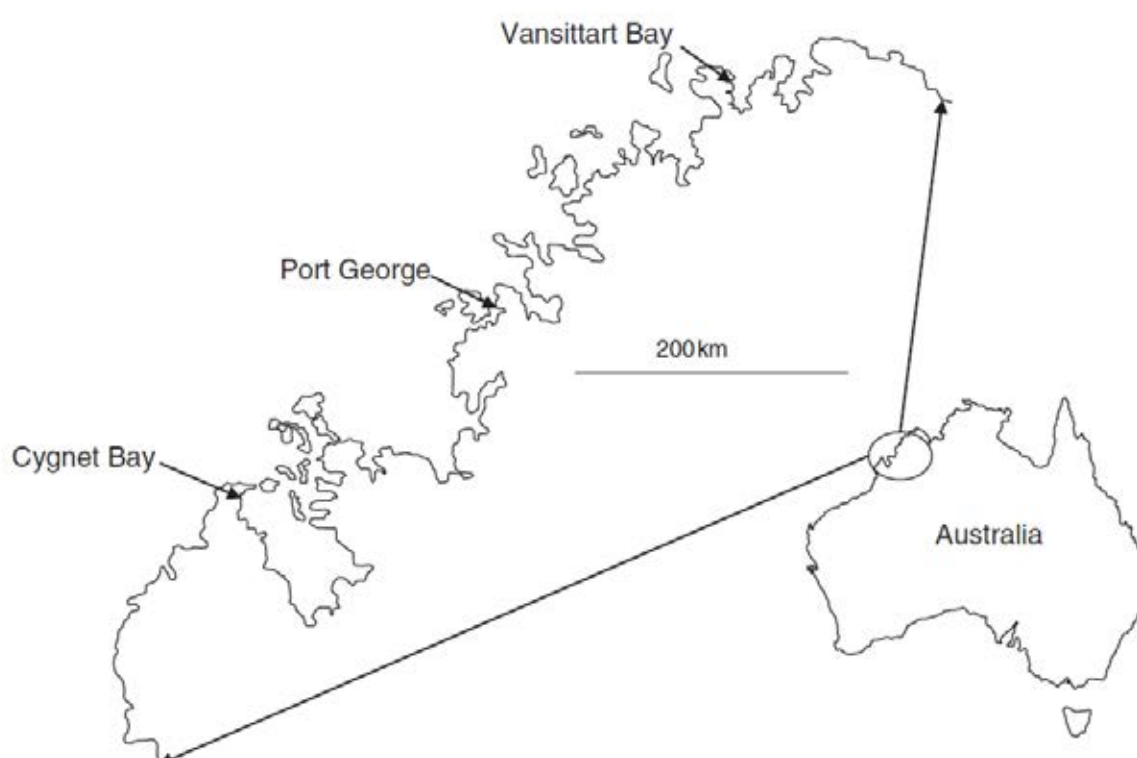


Figure 12.19. Map of Australia showing Kimberley coast region and study areas: Cygnet Bay, Port George and Vansittart Bay. Source: Jelbart et al. (2011)

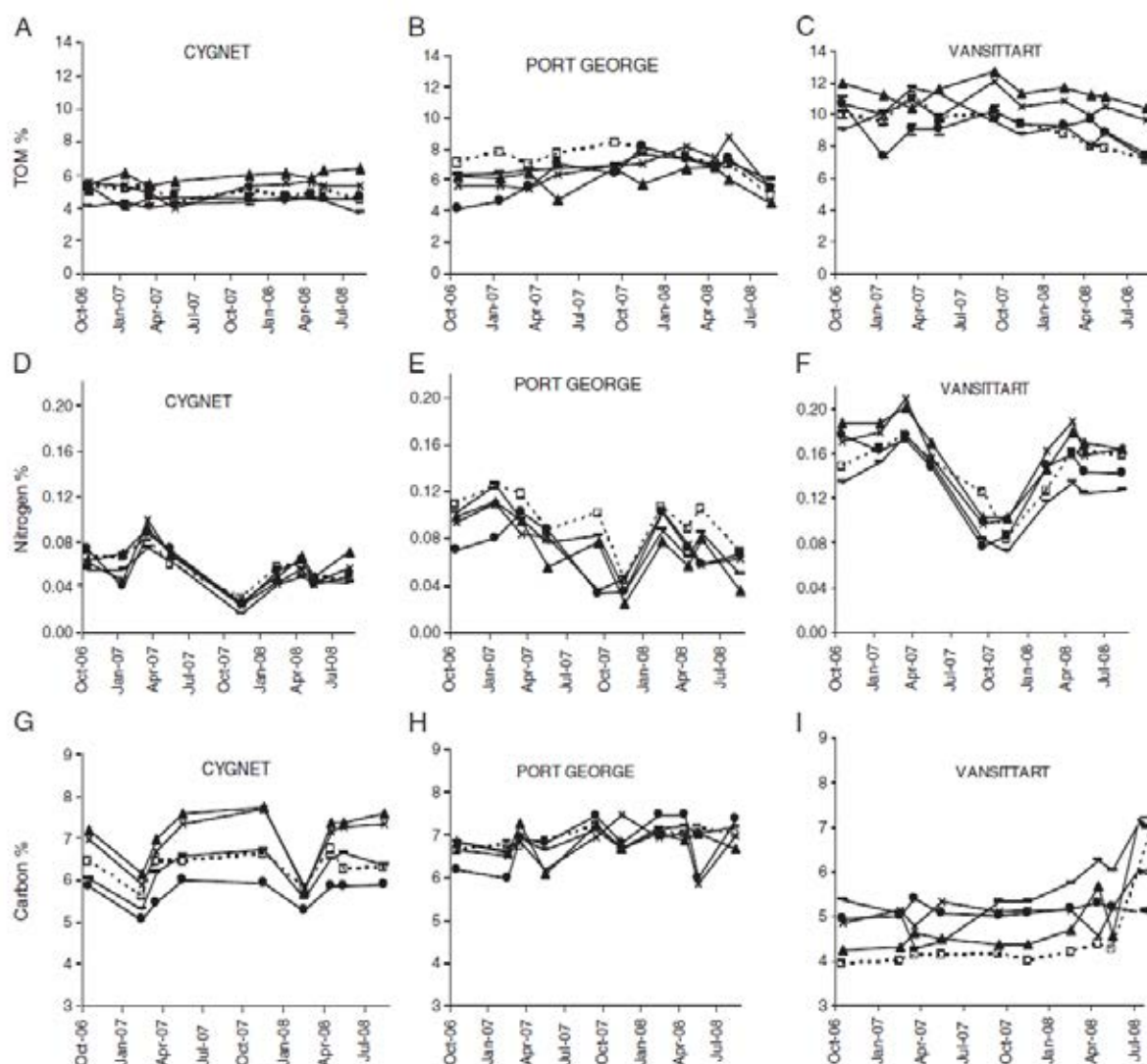


Figure 12.20. The percentage of total organic matter, nitrogen and carbon in the soft sediments at each bay over two years sampling among farm (dashed line) and reference locations (solid lines). Farm = □, Reference 1 = —, Reference 2 = ▲, Reference 3 = ×, Reference 4 = ●. Source: Jelbart et al. (2011)

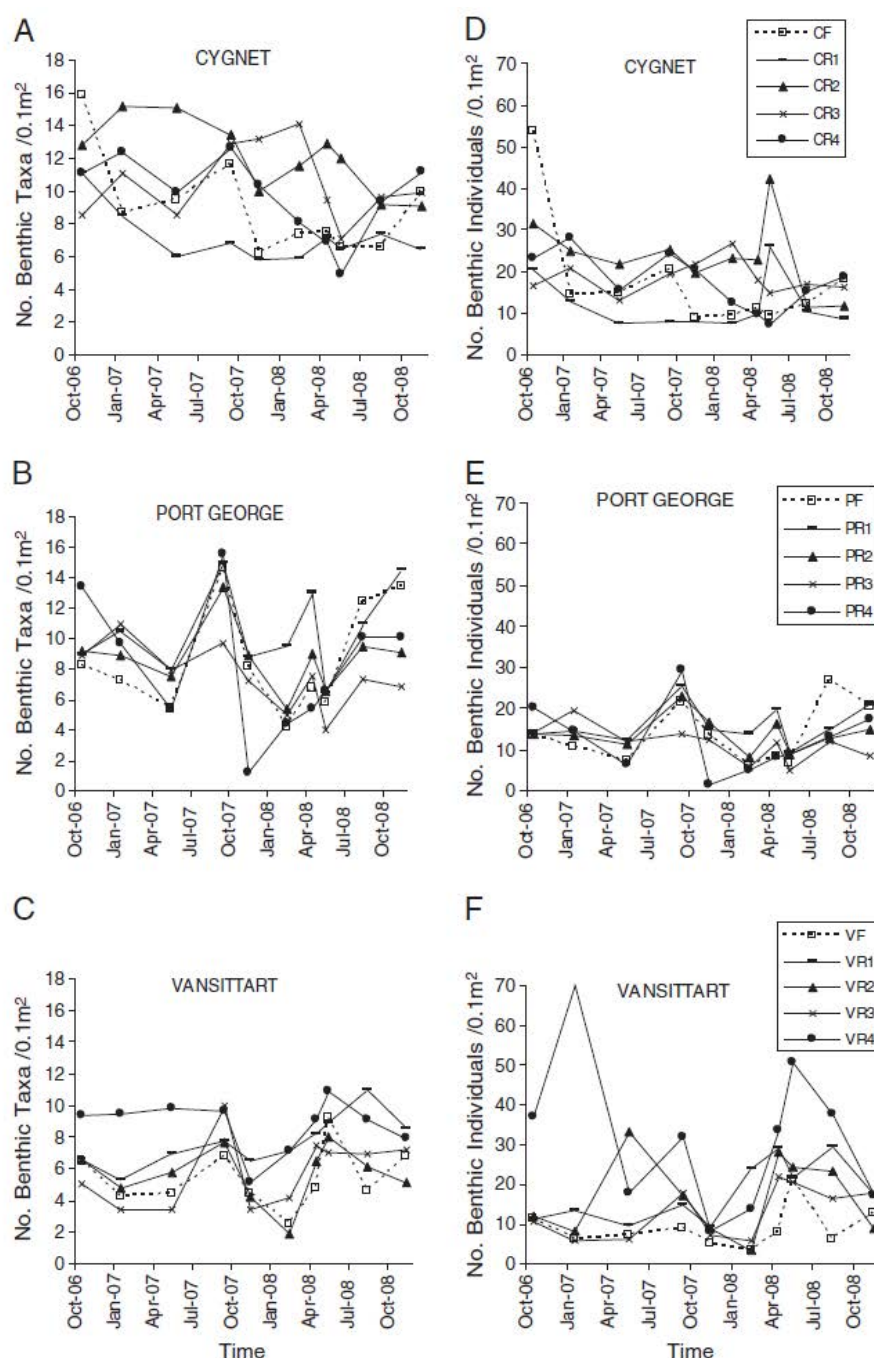


Figure 12.21. Number of macrobenthic taxa (species to families) and individuals per 0.1 m² of soft sediments at each bay over two years sampling among farms (F) and reference (R) locations. Source: Jelbart et al. (2011)

This study also investigated the effects of removing a pearl oyster farm lease (Otama pearl farm, near Kuri Bay, WA) on the benthic conditions under the farm lease compared to nearby reference locations. The farm lease was not used from November 2006, and all adult pearl oysters were removed from the longlines (some juvenile shell remained for a few months). Sampling was conducted 1 – 6 months before the farm was closed ('before'); 6 – 12 months after removal of the pearl oysters ('one year after'); and 18 – 24 months after closure ('two years after'). The benthic conditions under the farm lease were compared to three similar

reference locations at least 1 km from the site. The fluctuations in the sediment nutrient levels (total organic matter, carbon, nitrogen and carbonates) under the longlines at the farm lease were within the bounds of what occurred naturally at the reference locations, both before and after pearl oyster removal. There were no differences between what was observed in the sediments at the farm compared to the reference locations, or any significant differences before and after pearl oyster removal. These results suggest that the pearl oyster farm lease had no impact on the sediments or benthic fauna of the site (McCallum & Prince 2009).

12.3.4 Risk assessment outcomes

The impact of fishing activities on habitats have been assessed using a risk based approach (see Section 2.5). The results and justifications of the most recent risk assessment are provided below.

12.3.4.1 Diver activities

2015 ERA Risk Rating: Impact of diver activities on benthic habitats (C1 L1 Negligible)

Pearl oyster divers carry with them several pieces of equipment for safety and pearl oyster collection purposes. This includes the underwater breathing apparatus (such as surface supplied air units) and a large mesh bag for storage of the catch (with capacity of between 100 and 200 live pearl oysters). Divers operate above the substrate, not making contact with the bottom. This is to their advantage, as contact with the bottom may cause turbidity reducing visibility and therefore their ability to locate pearl oysters. Additionally, diver equipment is neutrally buoyant. Divers have deck tenders to monitor their lines and assist in ensuring that contact with the substrate does not damage equipment and hinder diving operations. This, in turn, ensures that the substrate is not negatively impacted (Fletcher et al. 2006).

12.3.4.2 Anchoring

2015 ERA Risk Rating: Impact of anchoring on benthic habitats (C1 L1 Negligible)

Pearl oyster vessels do not anchor in the course of daily fishing but need to anchor at night when the crew and skipper are on standby. Pearl oyster vessels operating at remote pearl oyster fishing locations and cannot afford to anchor over complex habitat for the fear of fouling the anchor and losing precious fishing time over the neap period. Therefore, pearl oyster vessels anchor over sand, as sand is generally less affected by the presence of an anchor and better meets the vessel safety requirements.

12.3.4.3 Holding and dump sites

2015 ERA Risk Rating: Impact of pearl oyster holding and dump sites on benthic habitats (C1 L2 Negligible)

The impact of holding and dump sites is generally temporary and localised, it is considered to have a negligible impact on the seafloor. The Pearl oysters are held in mesh panels and placed on the seabed for several weeks, prior to seeding operations (note: seeding can occur on a holding site or farm lease). The panels are generally located on sandy patches close to the pearling grounds.

12.3.4.4 Farm leases

2015 ERA Risk Rating: Impact of pearl oyster farm leases on benthic habitats (C2 L1 Negligible)

12.4 Management strategy

A number of measures are used to minimise the impacts of fishing activities on habitats within the NCB. Habitats are primarily protected through spatial closures / zoning implemented and managed by the Department, DPaW and / or DotE. Different degrees of protection are afforded to areas in accordance with categories established by the International Union for the Conservation of Nature (IUCN). These categories range from sustainably-managed multiple use areas (Category IV) to complete no-take areas, where no extractive activity is permitted (Category I). Spatial closures are identified following a risk-based assessment of ecological parameters within a defined bioregion and can involve total or partial closures to fishing activity. Closures can be used alone but are often used in combination with other fisheries management tools (e.g. effort limitations, gear restrictions) to achieve specific objectives (Fletcher & Santoro 2014). Habitat protection measures within the Pilbara and Kimberley regions include:

- Spatial closure to trawl-based fisheries under the FRMA (IUCN Category IV; 41 % of total shelf area in NCB);
- Total fishing closures (under section 43 of the FRMA) at Point Samson¹⁴ and the Kunmunya & Samson II wreck¹⁵ at Delambre Reef;
- Total fishing closures within Commonwealth Marine Reserve areas at Mermaid Reef, Ashmore Reef, and Cartier Island;
- Commercial and recreational fishing closures within the Barrow Island Marine Park and Montebello Islands Marine Park and the Rowley Shoals Marine Park (in line with zoning outlined in the marine park management plans); and
- Other gear restrictions¹⁶ (under section 43 of the FRMA), e.g. prohibition on use of a fishing net in Roebuck Bay¹⁷.

There is a specific strategy in place to manage the WA pearling industry's impacts on benthic habitats, which utilises management measures under the PA, PR and MPGs. As per the harvest strategy, the POF has a long-term objective for habitats *to ensure the effects of the pearling industry do not result in serious or irreversible harm to habitat structure and function*. There are a number of measures in place to achieve this objective, including:

- Legislated requirement to collect pearl oysters by hand;

¹⁴ [http://www.slp.wa.gov.au/statutes/subsidiary.nsf/0/74446C861FFBCF63482571BC00241001/\\$file/4.34\[1\].pdf](http://www.slp.wa.gov.au/statutes/subsidiary.nsf/0/74446C861FFBCF63482571BC00241001/$file/4.34[1].pdf)

¹⁵ [http://www.slp.wa.gov.au/statutes/subsidiary.nsf/0/9371E2B70EFF6D3648256FAC002D896A/\\$file/4.25\[1\].pdf](http://www.slp.wa.gov.au/statutes/subsidiary.nsf/0/9371E2B70EFF6D3648256FAC002D896A/$file/4.25[1].pdf)

¹⁶ <http://www.slp.wa.gov.au/statutes/subsidiary.nsf/FisheriesO?OpenPage&Start=1&Count=30&Expand=2.2>

¹⁷ [http://www.slp.wa.gov.au/statutes/subsidiary.nsf/0/23013B11F5D772FA48257C450015E564/\\$file/4.44+\[0\]+17.12.13.pdf](http://www.slp.wa.gov.au/statutes/subsidiary.nsf/0/23013B11F5D772FA48257C450015E564/$file/4.44+[0]+17.12.13.pdf)

- Size limits and catch quotas on the number of pearl oysters that can be collected annually;
- Spatial management via zoning;
- Minimum distances requirements between farm leases and holding sites;
- Restrictions on the size of holding sites and farm leases.

The pearling industry has also established a number of initiatives to minimise and monitor impacts, including the implementation of an industry Environmental Code of Conduct. The Environmental Code of Conduct includes a number of activities to guide best environmental practices including (1) protecting the environment; (2) complying with regulations; and (3) treating aquatic animals responsibly (PPA 2008b).

Individual pearl oysters are collected by hand by highly-trained divers as they are towed over the seafloor. In order to maximise the efficiency of collecting pearl oysters, a high level of care is taken to minimise contact with the seafloor during diving operations. Pearl oyster holding sites and farms leases are subject to regulations on size; distance from other holding sites and/or farm leases; and suggestions on the density / number of pearl oysters that can be held. This limits the impacts from cultivation activities to localised areas and provide for large areas of refuge from farming activities. The total area (application of farm leases) of sea bed that can be used for cultivation by a company is based on the quota units allocated and/or pearl oyster stock holdings for each company. Therefore, the company's total leased areas need to be within this requirement.

The habitats used by the pearling industry are well documented, and pearl oyster collection and cultivation does occur in any sensitive habitats or vulnerable marine ecosystems, such as seagrass beds or coral reefs. The impacts of the pearling industry in WA have been investigated as part of multiple research projects over the last 20 years (e.g. WA Museum 1997; Enzer Marine Environmental Consulting 1998; Jernakoff 2002; Prince 1999; McCallum & Prince 2009; Jelbart et al. 2011), with little evidence of environmental impacts from the sustained presence or ongoing operation of the pearling industry in the NCB over the last 150+ years.

Ongoing fishery performance against the long-term objective for habitats is measured and monitored annually via the Harvest Strategy. The POF has a short-term (annual) objective for habitats that: *'fishery impacts are considered to generate an acceptable level of risk (i.e. moderate risk or lower) to habitats'* (DoF 2016). In the most recent risk assessment (2015), the pearling industry was considered to be a negligible risk to habitats. Compliance with management measures is monitored by field officers based in Karratha and Broome, who patrol the entire area in which the pearling industry operates (see Section 16.3).

12.5 Information and monitoring

The nature and distribution of habitats within Exmouth Gulf and along the Pilbara Kimberley coasts has been described and mapped as part of a number of research projects and continues to be investigated as part of ongoing research conducted by the Department, other State and

Commonwealth agencies and academic / research institutions (see Sections 12.1.1 – 12.1.3 above). Additionally, in 2011, the WA Government released the Kimberley Science and Conservation Strategy to “...recognise and conserve one of the world’s last great wilderness areas”. This Strategy includes a Kimberley Marine Research Program, with the goal of undertaking a program of marine research to support the management of the newly gazetted and proposed State marine parks. Proposed research themes include:

- Habitat mapping, biological survey, marine fauna distributions and associated assessments;
- Characterisation and predictive capacity of the nature and levels of human usage and potential impacts;
- Characterisation, understanding and predictive capacity of key ecological processes;
- Biological implications and potential adaptations to climate change;
- Development of cost-effective indicators and methodologies for long-term monitoring; and
- Understanding and applying Indigenous coastal knowledge for marine biodiversity conservation and resource management (Simpson 2011).

Along with the above projects, the Department is involved in a number of current and future research projects within the new Lalang-garram / Camden Sound Marine Park and greater Kimberley region.

The pearling industry has recognised a variety of bottom types within the fishing and cultivation areas, e.g. ‘garden’, ‘potato’, ‘asparagus’, etc. Divers report the location of fishing activities, along with habitat type, depth and water visibility in their *Pearl Oyster Fishery Daily Logsheets*. This information is used by the Department to monitor fishing activities within the various habitat types and is used to detect any increase in risk to habitats.

13. Ecosystem

13.1 Overview

The northwest coast of WA is generally characterised by its wide continental shelf, very high tidal regimes, high cyclone frequency, unique current systems and warm oligotrophic surface waters (Brewer et al. 2007). Marine waters are generally low in nutrients due to the suppression of upwelling by the dominant Indonesian Throughflow, with seasonal changes in the region's oceanography the primary driver of biological productivity within the region. Seasonal occurrences include the weakening of the Throughflow, seasonal reversal in wind direction, internal tides, thermocline depth and episodic events, such as cyclones. As a result of the periodic nature of these events, productivity on the region is sporadic and follows 'boom and bust' cycles (CoA 2007).

The weakening of the Indonesian Throughflow and Leeuwin Current in the dry season (April to September and particularly during El Niño years), along with the seasonal reversal in wind and cyclones, enhances biological productivity through increased mixing of the deeper, cold, nutrient-rich waters with surface waters (DEWHA 2008). Benthic productivity on the shelf is constrained at the coast by high turbidity and lack of nutrients, while at the mid-shelf, nutrients are higher and light levels are moderate. Coastal waters are generally low-energy in terms of wave action but are seasonally influenced by infrequent, but intense, tropical cyclones, storm surges and associated rainfall run-off. Shelf regions are highly dependent on physical processes that transport nutrients from the offshore into the bottom of the water column and towards the coast. Benthic production is thus likely to increase away from the coast before declining again in deeper water on the outer shelf (Brewer et al. 2007); however, some locations along the outer shelf have predictably higher productivity, including the coral reefs along the shelf edge including Ashmore, Scott, Seringapatam and the Rowley Shoals and carbonate banks and pinnacles of the Sahul Shelf (CoA 2012).

Many species and communities have adapted to the sporadic nature of productivity in the region and are able to utilise food sources when and where ever they become available. In the water column, injections of nutrients are quickly utilised through rapid regeneration of primary consumers, such as microzooplankton (e.g. protozoa) and macro/mesozooplankton (e.g. copepods and other filter-feeders). Gelatinous zooplankton (e.g. salps) and jellyfish also play an important role in the food web as both primary and secondary consumers (CoA 2007). These species represent a large proportion of the marine biomass and provide a food source for many pelagic fish species, such as tuna, billfish and lutjanids, long after the initial burst in primary production has dissipated (DEWHA 2008).

13.2 Trophic modelling

Bulman (2006) developed a model of the trophic system of the northwest shelf region, which was later reviewed and incorporated into an approach by Brewer et al. (2007) to describe and develop conceptual trophic models of the broader North West Marine Region of Australia (NWMR; Kalbarri to the WA/NT border). Key aspects of Brewer et al.'s approach were the

aggregation of biological trophic information to the functional group level, explicit incorporation of habitat information and key drivers and the identification of services provided by, or linkage between, systems of the NWMR. This step involved identifying regional drivers, and using any existing quantitative models, data, publications and expert opinion to develop trophic models that were broadly representative of those in the NWMR (Brewer et al. 2007).

A generic model was implemented in the NWMR by identifying the broad regional differences in oceanographic forcing that would affect trophic systems. Key considerations included:

- A review and qualitative assessment of drivers of the trophic systems in the NWMR (e.g. oceanography, sediments, geomorphology, productivity/ nutrients, climate, habitats, species composition and terrestrial inputs);
- A description of how the trophic systems of the NWMR may differ from other marine regions around Australia because of their component species and/or habitats;
- The identification of important habitats/species based on their role in trophic systems; and
- The collection of information from literature reviews and separate consultation with experts.

From this approach, a generic conceptual representation of how the region, sub-regions, their trophic systems and important features all related to each other was developed (Brewer et al. 2007). This information has been used to compile a *Bioregional Profile for the Northwest Marine Bioregion* by the Commonwealth Department of Environment, Water, Heritage and the Arts (currently DotE; DEWHA 2008). A summary of the trophic and ecosystem descriptions compiled by Brewer et al. (2007) and DEWHA (2008) are provided below.

13.2.1 North West Shelf Region — North West Cape to Dampier Peninsula

Trophic modelling using *Ecosim/Ecopath* methodology was done for the North West Shelf (NWS; Exmouth Gulf and Pilbara coast) as part of the NWSJEMS by Bulman (2006). The model represents the food web of the continental shelf ecosystem in the depth range of approximately 20 to 200 m. The seabed in this area supports a high biodiversity and a variety of benthic habitat types, including soft muds on the outer shelf, coarse sands and occasional limestone outcrops over most of the shelf, sponge and soft coral ‘gardens’ and coral reefs. The fauna of the NWS ecosystem (50 – 200 m depths) was organised into functional groups, based upon commercial fishery, life history traits and ecology, such as size and growth, preferred depth and trophic function. A matrix of trophic interactions was constructed based upon a preliminary inspection of past dietary studies made on the NWS and for the same or similar species in the Gulf of Carpentaria where NWS information was lacking (Bulman 2006).

A conceptual model was proposed from this dietary data, with the conceptual model groups forming the basis for the final structure of the trophic model (Figure 13.1). The food web has shallow (20 – 20 m depth) and deep (120 – 200 m depth) components to reflect both the major differences on community structure in these different depth ranges and the ontogenetic migrations from shallow to the deep communities by some species (Bulman 2006). A dominant group in the ecosystem were the nemipterids, which represented more than 10 % of the estimated fish biomass and consumed about 9 % of all the fish consumed in the system (Table 13.1). Lizardfishes represented only about 1.5 % of fish biomass, but their highly piscivorous diet meant that they consumed 4 % of all fish consumed in the system, mostly small demersal and pelagic fish. In terms of biomass, the small pelagic and the small demersal fish groups were the largest, comprising 34 % and 26 %, respectively, of the fish biomass and were the most eaten (31 % and 17 %, respectively, of total consumption of fish in the system). Small pelagic fish group were responsible for 6 % of the total fish consumption, even though they were mostly plankton feeders, because of their high biomass rather than the high proportion of fish in the diet composition. In addition, other small fish groups were also relatively abundant, and over all, the small fish categories accounted for at least three-quarters of the fish biomass. In contrast to the high biomasses of the small fish groups, the relatively low biomass of squid ate the highest proportion of all fish eaten (13 %) as a result of their preference for small pelagic fishes (Bulman 2006).

Food Web of the North West Shelf

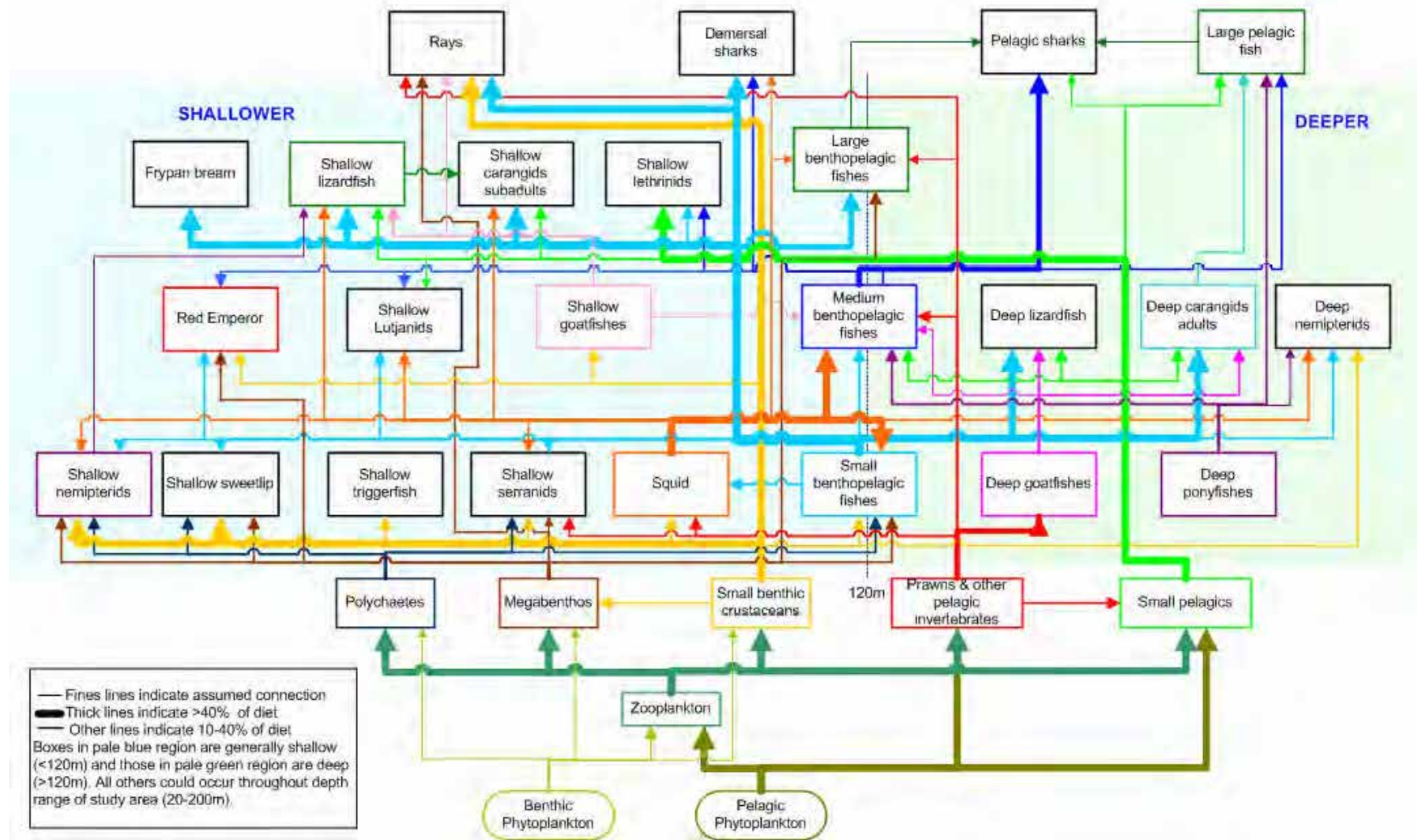


Figure 13.1. Food web of the North West Shelf. Coloured arrows represent flows from boxes of the same colour. Source: Bulman (2006)

Table 13.1. Relative importance of trophic groups as proportions of the total estimated fish biomass in the northwest shelf system and as proportions of fish eaten in the system. Source: Bulman (2006)

Trophic group	Proportion of fish biomass	Proportion of total consumed fish	Proportion of total fish consumed by group
Coastal sharks	0.001	0.0004	0.0001
Rays	0.003	0.0008	0.0001
Small tunas	0.003	0.0010	0.0064
Shallow lethrinids	0.004	0.0028	0.0044
Red emperor	0.004	0.0020	0.0052
Shallow lutjanids	0.008	0.0044	0.0150
Shallow nemipterids	0.074	0.0650	0.0549
Deep nemipterids	0.029	0.0275	0.0231
Shallow serranids	0.001	0.0005	0.0014
Frypan bream	0.001	0.0007	0.0027
Juvenile carangids	0.022	0.0109	0.0374
Adult carangids	0.029	0.0147	0.0330
Small pelagic fish	0.338	0.3104	0.0662
Shallow lizardfish	0.011	0.0090	0.0289
Deep lizardfish	0.004	0.0024	0.0104
Shallow mullids	0.056	0.0726	0.0130
Deep mullids	0.100	0.1354	0.0206
Trigger fish	0.005	0.0029	0.0003
Sweetlips	0.003	0.0020	0.0036
Pony fish	0.028	0.0574	0.0043
Shallow small fish	0.181	0.1728	0.0361
Deep small fish	0.076	0.0898	0.0122
Shallow medium fish	0.011	0.0086	0.0103
Deep medium fish	0.002	0.0012	0.0010
Shallow large fish	0.007	0.0049	0.0094
Deep large fish	0.000	0.0000	0.0001
Commercial prawns		0.7718	0.0075
Squid		0.0934	0.1309

The sandy substrates on the shelf of this region are thought to support low densities of benthic communities of bryozoans, molluscs and echinoids. Sponge communities are also sparsely distributed on the shelf but are found only in areas of hard substrate. The region between Dampier and Port Hedland has been described as a hotspot for sponge biodiversity (Hooper & Ekins 2004). This biodiversity may reflect the tendency of sponge larvae to settle out of the water column very quickly, resulting in minimal larval exchange and high population differentiation between sponge communities. Other benthic and demersal species in this region include sea cucumbers, urchins, prawns and squid (DEWHA 2008). The benthic and pelagic fish communities of the NWS region are strongly depth-related,

indicative of a close association between fish communities and benthic habitats (Brewer et al. 2007).

The warm, low salinity waters of the Indonesian Throughflow generally suppress upwellings in the NWS region; however, biological productivity is thought to be stimulated through the action of physical drivers such as internal waves, tidal stirring and cyclones. Broadly, the inner shelf experiences oligotrophic conditions, with episodic injections of nutrients during storm events when run-off from terrestrial sources occurs and when sediments are resuspended as a result of cyclonic or tidal activity. Enhanced pelagic production occurs on the outer shelf as a result of the interaction of surface and deeper water masses on the adjacent shelf break via vertical mixing and possibly internal wave action. The mixed water masses travel towards shore and can stimulate biological productivity when the deeper nutrient-rich waters move into the photic zone where light allows phytoplankton to take up the influx of nutrients; however, such upwelling events are likely to be sporadic and short-lived (DEWHA 2008).

Primary productivity in the NWS region is thought to occur predominantly in pelagic environments, where phytoplankton plays an important primary producer role. Phytoplankton species rapidly multiply in response to bursts in nutrient availability and are subsequently consumed by zooplankton, which are in turn consumed by small pelagic fish. Higher order tertiary consumers, including squid, mackerel and seabirds, feed on small pelagic fish. Scavengers such as crabs, shrimps and demersal sharks, and fish species such as queenfish, mackerel, king salmon and barramundi may also be common (Brewer et al. 2007). Transient tertiary consumers such as tuna, snapper species and toothed cetaceans provide a link between the pelagic and benthic systems, as they prey on demersal and pelagic species. Small amounts of detritus falling to the seafloor provide another link between the pelagic and demersal systems and are utilised by sparse benthic communities of sponges and sessile filter-feeders (DEWHA 2008). An overview of the trophic structures of the NWS region is provided in Figure 13.2.

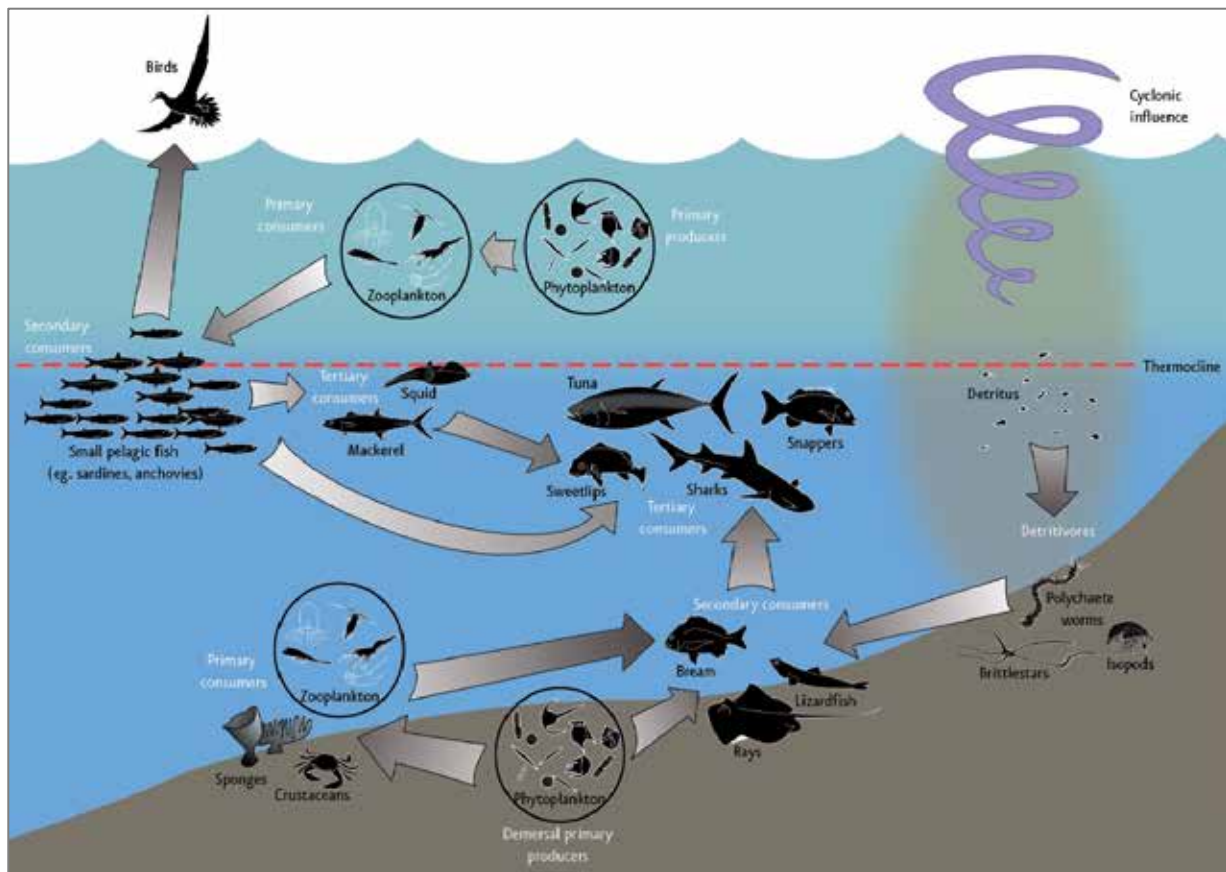


Figure 13.2. Trophic structures of the North West Shelf region. Source: DEWHA (2008)

13.2.2 Kimberley Shelf Region — Dampier Peninsula to western Joseph Bonaparte Gulf

The trophic system of the Kimberley shelf region is influenced from the Indo-Pacific Throughflow (e.g. temperature regime and productivity), internal breaking waves and benthic re-suspension on the mid- to outer-shelf and terrestrial freshwater inputs in the coastal areas, especially from the Prince Regent and Fitzroy Rivers. This region is unique in the NWMR as having the highest cyclone impact, low mud and high gravel content in the sediments and the highest concentration of silicate compared to the other regions. There is an influx of nutrients from coastal runoffs and from outer-shelf mixing, although the warm, low salinity waters of the Indo-Pacific Throughflow depress productivity in the surface waters. This region is highly dynamic, however, with the factors affecting productivity generally not well understood (Figure 13.3; Brewer et al. 2007).

The nutrients inputs, along with year-round high light levels, and seasonal mixing provide the ingredients for phytoplankton-based system in a large part of this subregion. These conditions support a deep chlorophyll maxima at about 70 m depth where more nutrient rich waters are sporadically mixed with the surface layer due to the influence of internal breaking waves on the shelf, seasonal winds and cyclonic events (Figure 13.3). The shallower coastal turbid zone is poorly understood but may support significant populations of filter-feeding invertebrates, such as sponges and bivalves, and scavengers such as crabs, shrimps and demersal sharks and

fish. There is likely to be an abundant demersal community dominated by primary and secondary consumers; however, little is known of their species composition in this zone. Tertiary consumers are also poorly understood in this coastal zone but are likely to include queenfish (*Scomberoides* spp.), mackerel (*Scomberomorus* spp.), king salmon (*Elutheronema tetradactylum*) and barramundi (*Lates calcarifer*; Brewer et al. 2007).

The effects of seasonal influences on these trophic systems are not clearly understood. The high incidence of cyclones and freshwater input during the summer monsoon provides mixing and nutrients during this time, and strong offshore winds provide nutrients into the water column from upwelling off the continental slope, especially in winter. Surface chlorophyll concentrations appear to be relatively high in this sub-region throughout the year (Hayes et al. 2005) indicating a constant nutrient supply, possibly dampening any major seasonal effects on trophic system dynamics; however, it may be that species in the coastal zone use the summer productivity to drive feeding and reproductive patterns and that the more offshore regions of the shelf do the same in winter. Like other shelf systems, the link between the pelagic and benthic communities is strong in the shallower inshore part of the shelf where strong tidal currents, monsoonal winds and sporadic cyclones mix the water column and associated nutrients (Brewer et al. 2007).

Trophically-important species in the Kimberly Shelf region may include the large epibenthic invertebrate species that provide shelter, food and structural diversity for the channels, banks, islands and shoals that characterise this region (Figure 13.4). These are poorly studied but are likely to include gorgonians, sponges, hard and soft corals, bryozoans, ascidians and echinoderms. These ultimately support higher order predators, such as Lutjanid snappers (especially *L. sebae*, *Pristipomoides multidens* and *L. malabaricus*), Lethrinid emperors or sweetlip (especially *L. nebulosus*) and various cods and groupers (Serranidae). These species are also likely to play a critical role in regulating the demersal community structure and composition. A range of pelagic higher order predators may also be playing a key role in controlling trophic system dynamics of the region, including mackerels (especially Spanish mackerel, *Scomberomorus commerson* and grey mackerel, *S. semifasciatus*), tuna (especially Bonito, *Sarda australis*; Yellowfin tuna, *Thunnus albacares*; Longtail tuna *T. tonggol* and Skipjack tuna, *Katsuwonus pelamis*), Dolphinfin (*Coryphaena hippurus*) and various species of trevally (Carangidae; Brewer et al. 2007).

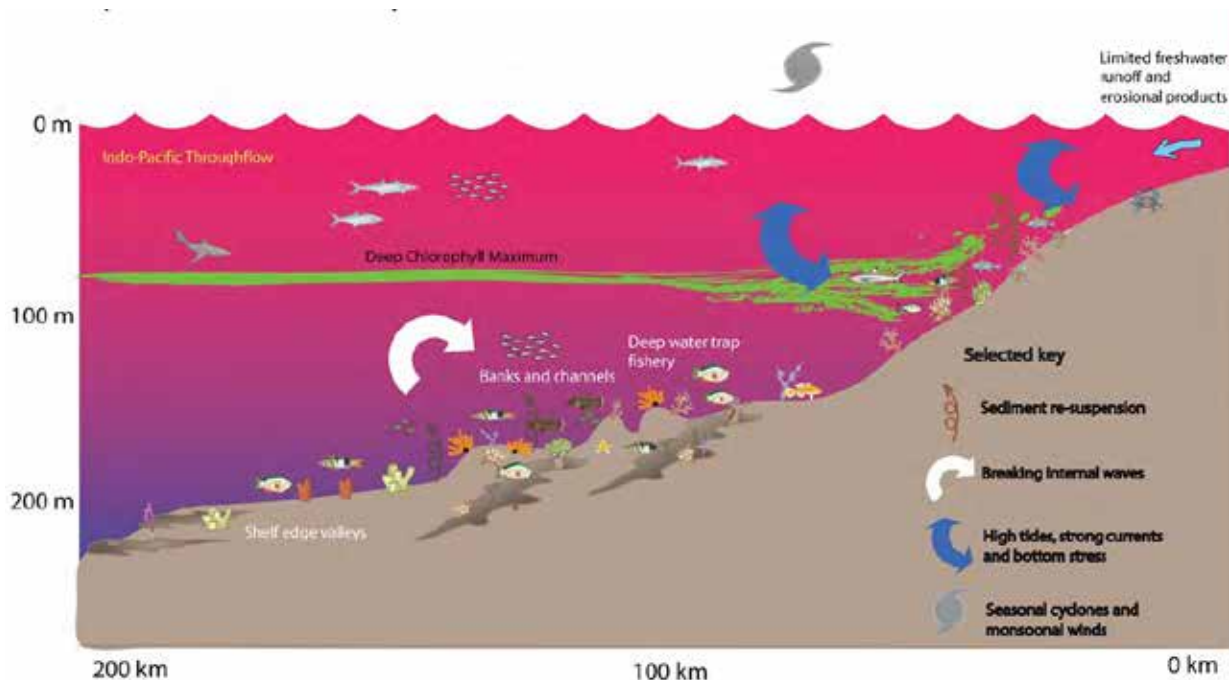


Figure 13.3. Habitat diagram of the Kimberley Shelf region showing selected important drivers and features. Source: Brewer et al. (2007)

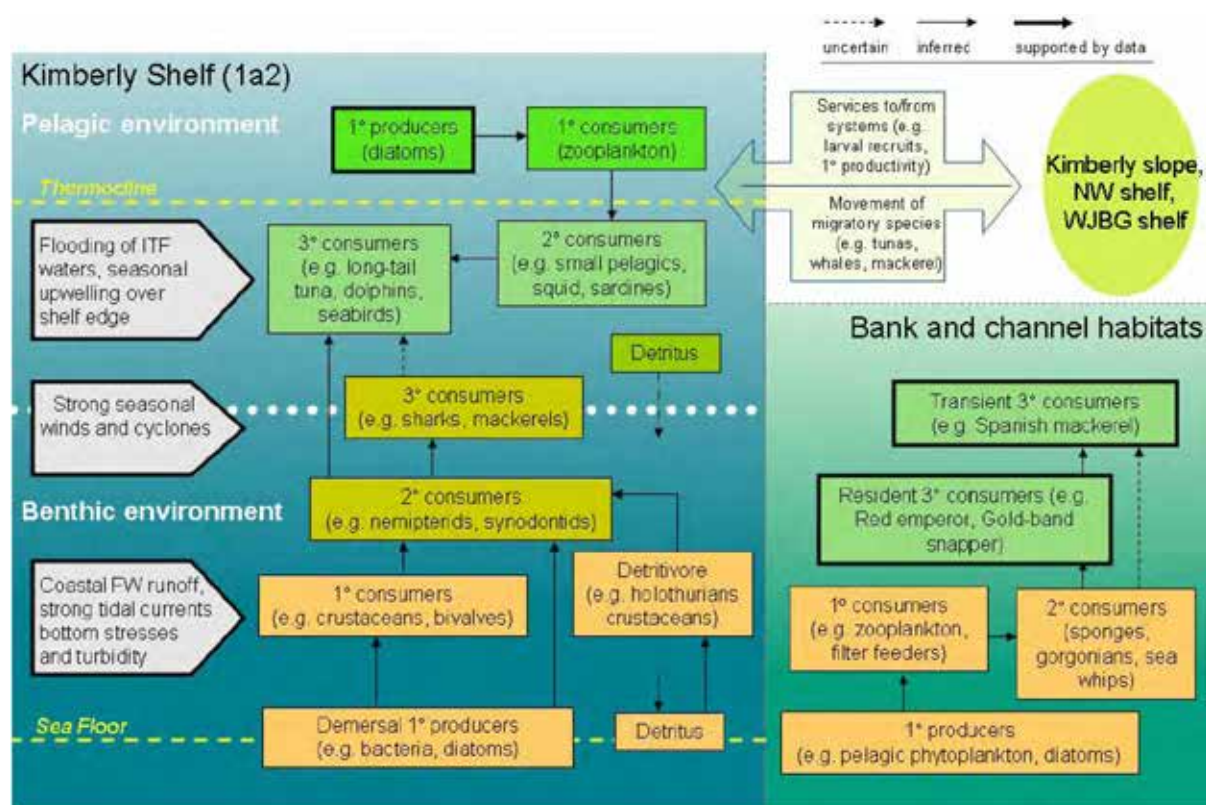


Figure 13.4. Conceptual trophic model of the Kimberley Shelf region showing information on the extensive habitat in the coastal and central shelf region (left) and the important bank and channel habitats in the central and southern areas (right). Source: Brewer et al. (2007)

13.2.3 Western Joseph Bonaparte Gulf Shelf Region

The western Joseph Bonaparte Gulf (JBG) shelf region is unique in the NWMR in having the shallowest depths (max. 271 m; ave. 84 m), high surface currents, second highest tidal exceedance, highest percent mud (and lowest percent carbonate content) in the sea bed sediments, highest sea surface temperatures, high nitrogen and phosphorus concentrations and highest chlorophyll concentrations. The Indo-Pacific Throughflow brings warm, low salinity water into the region from the tropical western Pacific Ocean and may drive upwellings of cold water onto the shelf from the deep Timor Trough to the north (Brewer et al. 2007).

The JBG inshore zone is characterised by terrestrial inputs of freshwater, sediments and detritus which are generally restricted to a distinct coastal boundary layer. The salinity of this sub-region is relatively low due to this influence. The sea bed sediments are comprised of relatively fine mud and silt with a highly turbid and mixed water column due to a combination of high tidal energy, strong monsoonal winds, cyclones and wind-generated waves, to a depth of about 20 to 30 m (Figure 13.5). Coastal productivity is supported by nutrients associated with sediments and detritus from the Ord, Pentecost, Durack and other river systems. The coastal trophic system is largely based on bacteria and other organisms that don't rely on sunlight or clear water. These organisms are attached to high concentrations of fine sediment and suspended floc particles. Phytoplankton production is also relatively high at the top of the water column, as indicated by high surface water chlorophyll concentrations (Hayes et al. 2005), but limited by light or at depth. The inshore communities of consumer organisms are poorly understood but are likely to be relatively abundant, based on the high productivity of the region and the productivity of the adjacent mid-shelf demersal communities. These communities are also likely to be highly diverse and unique to the region, like the adjacent mid-shelf communities (Figure 13.6; Brewer et al. 2007).

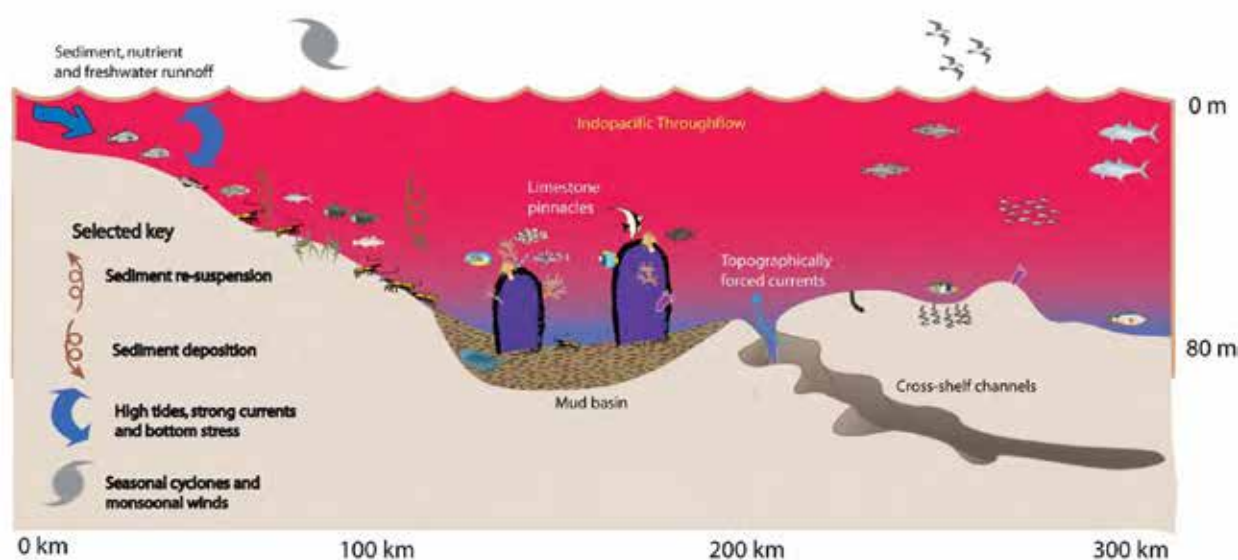


Figure 13.5. Habitat diagram of the western Joseph Bonaparte Gulf region showing selected important drivers and features. Source: Brewer et al. (2007)

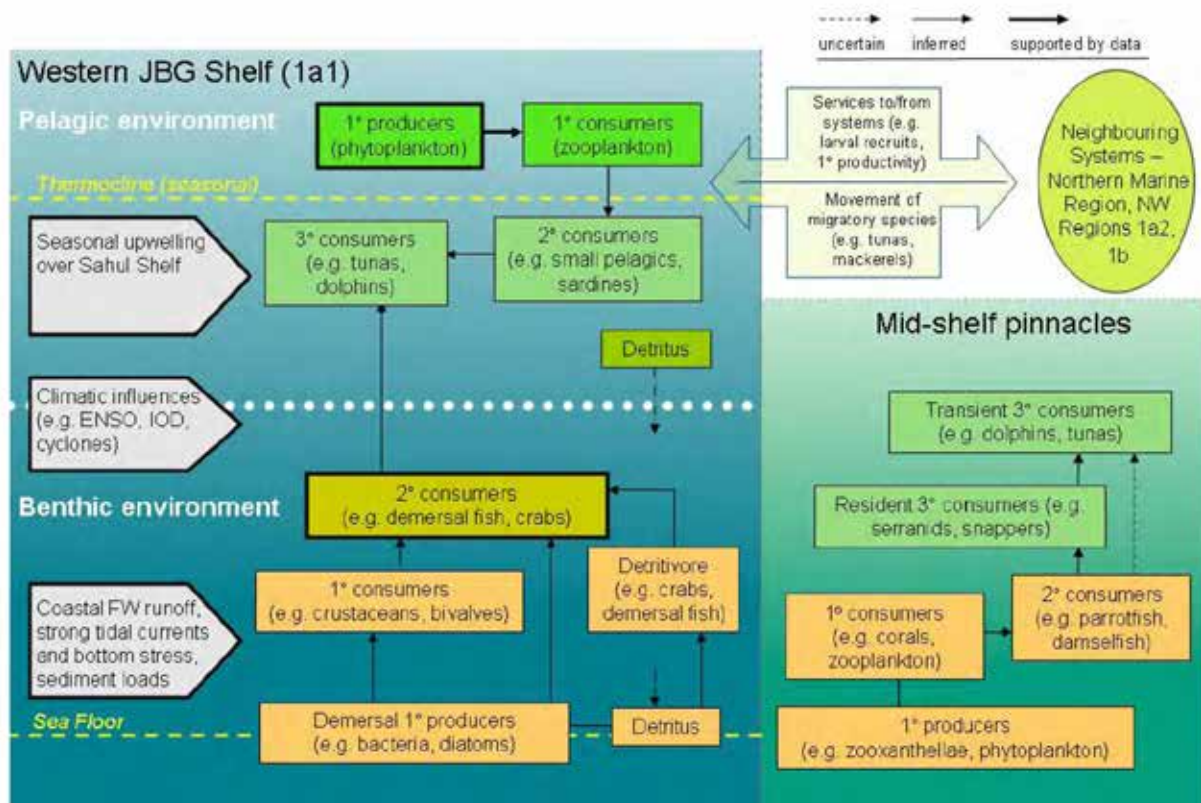


Figure 13.6. Schematic trophic model of the western Joseph Bonaparte Gulf region showing information on the extensive habitat in the coastal and central shelf region (left) and a less extensive, but important mid-shelf habitat (right). Source: Brewer et al. (2007)

13.3 Pearling industry impacts

Fisheries pose the risk of altering the benthic or demersal communities or changing prey availability through discards, such that food web dynamics shift. The main ecosystem impacts from pearling industry activities would be due to the removal of the target species, *P. maxima*, from the wild and impacts from the cultivation of this species on suspended culture systems on holding sites and farm leases throughout northwest WA.

There are no known obligate predators of pearl oysters, and trophic impacts from the removal of pearl oysters from the wild are considered to be negligible. Divers generally target a small size range of pearl oysters and are constrained by output controls of the POF, in the form of a TAC. Additionally, pearl oysters are found throughout the northwest region where there is suitable habitat, which includes most habitats apart from muddy substrate (Hart and Freidman 2004). Pearl divers are limited to shallower areas and calmer-weather seasons for safety reasons, providing areas and times of refuge from fishing activities for pearl oyster populations (Fletcher et al. 2006).

Bivalves such as pearl oysters gain nourishment by filtering suspended particles, such as phytoplankton and detritus, from the water column. Byproducts of this process are dissolved ammonium and biodeposits of feces and pseudofeces. Bivalves also sequester nitrogen in the form of protein in meat and shell and stabilise phytoplankton growth dynamics through the

moderation of ammonia cycling in the water column (Gallardi 2014). The resultant reduced concentrations of phytoplankton, a net loss of nitrogen from the system and a decrease in suspended matter is often viewed as a potentially positive effect in degraded estuaries; however, in areas relatively unaffected by human activities, it may result in a reduction of nutrients that are essential to the functioning of the ecosystem (Crawford 2001).

Ecological carrying capacity has been defined for shellfish aquaculture by Inglis et al. (2000) as “the stocking or farm density which causes unacceptable ecological impacts”. Gibbs (2007) discusses a number of issues around the definition and calculation of ecological carrying capacity, highlighting the fact that bivalve aquaculture can have an impact on the system because bivalves are both consumers (of phytoplankton) and producers (by recycling nutrients and detritus), with concomitant ecosystem impacts of both. Modelling has been used as an approach to examine environmental sustainability and to establish carrying capacity of shellfish aquaculture (e.g. Gerritsen et al. 1994; Raillard and Menesguen 1994; Ferreira et al. 1998; Bacher et al. 1998; Chapelle et al. 2000; Pouvreau et al. 2000; Gangnery et al. 2001; Niquil et al. 2001; Nunes et al. 2003). In French Polynesia, Niquil et al. (2001) examined the relationship between farmed pearl oysters (*P. margaritifera*) and the pelagic food web of the Takapoto Lagoon in order to determine the carrying capacity of the lagoon. Results indicated that there was a very low consumption of plankton by farmed bivalves compared to planktonic fluxes. When considering the whole lagoon, the farmed oysters (*P. margaritifera*) and associated bivalves (*P. maculata*) consumed 0.24 % of the planktonic gross primary production. Authors therefore concluded that oyster farming in the lagoon was far from being food-limited (Niquil et al. 2001). The influence of filter feeders (oysters and their epibiota) on the spatial distribution of particulate and dissolved compounds in the water column of Thau lagoon (French Mediterranean) was investigated by Souchu et al. (2001). The presence of densely-stocked oyster (*Crassostrea gigas*) farms led to a shift in phytoplankton composition that favoured picophytoplankton with higher growth rates; however, this seasonal (summer) increase in phytoplankton growth rate was stronger than the positive feedback due to filter feeder filtration. During this period, filter feeders were not food limited, while they tended to control phytoplankton biomasses and production during the rest of the year (Souchu et al. 2001).

In addition to studying the effects of cultured bivalves in coastal ecosystems by comparing nutrient concentrations and phytoplankton communities between bivalve-culture zones and adjacent areas (e.g. Baudinet et al. 1990; Mazouni et al. 2001; Souchu et al. 2001), there has also been research on the responses of communities in impacted coastal waters to system-scale removal of bivalve culture (e.g. Dame et al. 2002; Huang et al. 2008; Lin et al. 2009). Huang et al. (2008) assessed the impacts of removal by characterising changes in abundance, productivity levels and community structures of phytoplankton and periphyton before and after the complete removal of oyster (*C. gigas*) culture racks in a eutrophic, sheltered tropical lagoon in Taiwan (Tapong Bay). Before rack removal, phytoplankton and periphyton were the dominant autotrophs. After rack removal, neither periphyton chl *a* accumulation rate nor GP_{max} significantly increased, but the periphyton proportion of total system biomass was greatly reduced by the loss of available substrata for colonisation. In comparison,

phytoplankton chl *a* and GP_{max} remained at similar levels (after rack removal) in the outer region but increased 5-fold in the inner region. Bioavailable particulate organic matter derived from internal phytoplankton production was then expected to become the dominant food supply to the system after rack removal. While responses of phytoplankton to the removal of oyster culture racks were significant, tidal flushing was considered to play an important role in regulating phytoplankton responses to rack removal, with phytoplankton chl *a* and GP_{max} remaining low in the outer region of the lagoon (which is subject to faster flushing than the internal lagoon). Additionally, the removal of cultivated oysters (and associated mussels) resulted in increases in the cell number and changes in phytoplankton community structure, primarily from a release from bivalve filtration pressure. Phytoplankton communities in both the inner and outer lagoon and at the control site were dominated by Bacillariophyta alone before rack removal but shifted to a co-dominance of Bacillariophyta, Dinophyta and *Cyanobacteria* after rack removal. These results suggest that culture oysters in this eutrophic lagoon had effective top-down control of phytoplankton abundances and that they reduced the planktonic community diversity (Huang et al. 2008).

The extensive amount of research conducted on bivalve and oyster culture indicates that while farms have the capacity to alter ecosystem structure, impacts vary depending on factors such as farm size, oyster density, water depth, currents and season. Large-scale effects have only been documented in situations with high concentrations of oysters in water bodies with limited water exchange (Forrest et al. 2009).

The northwest coast of WA is known for its high tidal regimes and periodic (seasonal) productivity cycles (CoA 2007). Pearl oyster holding sites and farm leases are located throughout the northwest region, although the size and total area each company has is considered by the Department. MPG 8 and 17 are considered when an application for a new holding site or farm lease is received by the Department. This outlines that a Holding site and/or farm lease cannot be more than 4 nm² in size. A holding site must be more than 2 km from any other holding sites or more than 5 km from any pearl farm lease (unless there is mutual consent with the pre-existing area owner). Additionally, when applying for a new holding site, the applicant must not have a holding area within 20 nm of the proposed site. Farm areas must also be a minimum distance of 5 nm from other farm leases (unless there is mutual consent with the pre-existing area owner or they are owned by the same legal entity). Additionally, existing farm areas cannot expand to less than 2 nm from another existing area (see MPG No. 17). The area of seabed leased for cultivation (farm leases) is also matched to the area required based on the company's quota and pearl oyster stock holdings. Thus, if a company applies to establish a new farm lease the Department will assess the application in line with this formula. The pearling industry standard for the stocking density of pearl oysters is no more than 16 250 pearl oysters per square nautical mile. This density is much lower than densities used in other bivalve aquaculture activities where significant ecosystem impacts have been reported (Jelbart et al. 2011).

13.3.1 Risk assessment outcomes

The impact of fishing activities on the ecosystem has been assessed using a risk based approach (see Section 2.5). The results and justifications of the most recent risk assessment are provided below.

13.3.1.1 Removal of pearl oysters from the environment

2015 ERA Risk Rating: Impact of removing pearl oysters on trophic interactions (C1 L1 Negligible)

The removal of pearl oysters could result in a reduced removal of particulates from the water column due to the removal of a portion of filter feeders from the system; however, based on previous research into the effects of shellfish farms on primary productivity (e.g. Souchu et al. 2001), the removal of pearl oysters by the pearling industry is unlikely to present a significant change to the trophic structure of fished areas. These studies assessed the impact on the planktonic food web of shellfish held at higher densities (culture farms) than found in the wild. Results from these studies indicate that the effects of removal of the shellfish on phytoplankton availability can only be detected in the highest densities of shellfish and in waters of high residence. Furthermore, this result was only significant in winter when primary production was depressed (Souchu et al. 2001).

In the wild pearl oysters make up only a small proportion of filter feeders present, and removal of only a small part of this stock would not leave a measurable change to the level of primary productivity and other particulates in the water column. This is particularly the case for pearl oysters in this region given that a small percentage of the POF is fished (focused on areas in Zone 2/3), and significant quantities of pearl oysters still remain even in these fished areas. The removal of pearl oysters is also not expected to affect predators as divers target only a small size range of pearl oysters. Combined again with the relatively small areas where fishing operations occur and the lack of any obligate predator for pearl oysters, this suggests that this POF is having a negligible impact on any trophic interactions in this region (Fletcher et al. 2006).

13.4 Management strategy

There is a strategy in place to manage the WA pearling industry's impacts on the ecosystem, which utilises management measures under the PA, the PR and MPGs. As per the harvest strategy, the POF has a long-term objective for the ecosystem *to ensure the effects of the pearling industry do not result in serious or irreversible harm to ecosystem structure and function*. There are a number of measures in place to achieve this objective, including:

- Species restrictions limiting fishers to the take of *P. maxima* pearl oysters;
- Annual catch limits in the form a TAC for pearl oysters;
- Gear and fishing method restrictions;
- Size limits for pearl oysters;
- Spatial management via zoning;

- Minimum distances requirements between holding sites and/or farm leases;
- Restrictions on the size of pearl holding sites and farm leases;
- Restrictions on the total area that can be used for farm leases by each company; and
- Statutory reporting of catch and the location of fishing activities.

The pearling industry has also established a number of initiatives to minimise and monitor impacts, including the implementation of an industry Environmental Code of Conduct. The Environmental Code of Conduct includes a number of activities to guide best environmental practices including (1) protecting the environment; (2) complying with regulations; and (3) treating aquatic animals responsibly (PPA 2008b).

Ecosystem impacts from the removal of pearl oysters from the wild are limited by the annual TAC and associated quota unit values, which minimises the potential for trophic impacts from the removal of pearl oysters. Additionally, negative impacts on habitats and other species (including ETP species) are minimised by a number of spatial closures and specific strategies outlined in Sections 10.2, 11.3 and 12.4. Ecosystem impacts from cultivation aspects are limited by controls on the total area and size of holding sites and farm leases; minimum distances requirements between these areas and agreement on the density / number of oysters that can be held at each site. The location and size of the holding sites and farm leases is monitored, with coordinates of the areas provided by licensees at the time of application, and regular compliance inspections ensure these management requirements are met.

Based on research conducted in other oyster culture fisheries around the world, these measures are considered likely to work. Ecosystem impacts have been shown to vary depending on farm size, oyster density, water depth, currents and season, and large-scale effects have only been documented in situations with high concentrations of oysters in water bodies with limited water exchange (see Forrest et al. 2009 for a review). Additionally, the impacts of the pearling industry have been investigated as part of multiple research projects over the last 20 years (e.g. WA Museum 1997; Enzer Marine Environmental Consulting 1998; Jernakoff 2002; Prince 1999; McCallum & Prince 2009; Jelbart et al. 2011), with little evidence of environmental impacts from the sustained presence or ongoing operation of the pearling industry in the NCB over the last 150+ years.

There is clear evidence that the strategy is being implemented successfully and is achieving its objective. Ongoing fishery performance against the long-term objective for habitats is measured and monitored annually via the harvest strategy. The POF has a short-term (annual) objective for habitats that: *‘To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function’* (DoF 2016). In the most recent risk assessment (2015), the pearling industry was considered to be a negligible risk to the trophic system of the northwest shelf. Additionally, there is clear evidence that the pearling industry complies with the management measures in place based on compliance statistics (see Section 16.3).

13.5 Information and monitoring

There has been extensive research conducted on the ecosystems of the NCB, including trophic modelling of the North West Shelf region using an *Ecosim/Ecopath* approach (Bulman 2006) and the development of conceptual trophic models of the broader North West Marine Region of Australia (Brewer et al. 2007).

The impacts of oyster collection and cultivation on key ecosystem elements (i.e. trophic structure and function, community composition, productivity patterns and biodiversity) have been investigated in other parts of the world where oyster culture takes place (see summary in Section 13.3). The main impacts from these activities in the NCB, e.g. biodeposition and benthic organic enrichment and the carrying capacity impacts of localised phytoplankton depletion from bivalve filtration, can be inferred from this information.

Overall, wildstock licence holders are limited in their collection of pearl oysters by the TAC, with each licence holder limited to their annual quota (temporary transfers can occur within the POF). Fishers are required to report their catches to the Department daily via a *Pearl Oyster Fishing Daily Logsheet* (see example in Appendix E). Catches and quota are monitored by the Department's compliance staff based in Broome.

The size, total area and location of farm leases are constrained based on the quota and stock holdings of each company (MPGs; for a description of quota / farm area conversion calculation see Section 2.4). The extent and number of farm leases held by each company is known, with the company required to hold a current Pearl Oyster Farm Lease, which is granted by the Department under the PA. The annual extent of farm leases in the NCB is monitored by the Department.

14. Translocation

14.1 Overview

As part of industry operations, pearl oysters are moved among fishing areas and farm leases in WA and on some occasions from farm leases in WA to the NT. Translocation of pearl oysters occurs at various stages of the pearl cultivation process (see Section 2.3). Examples include the transport of

- wild-caught pearl oysters from fishing grounds to dump sites or holding sites;
- wild-caught oysters from dump sites and holdings sites to farm leases;
- wild-caught or hatchery reared oysters between farm leases;
- hatchery-reared oyster spat to nursery sites (separate farm lease or designated part of a farm lease); and
- pearl oysters for health testing.

Wells and Jernakoff (2006) provide context on the development and importance of translocation protocols in the pearling industry:

“During the late 1970s and early 1980s serious mortality of pearl oysters occurred in the transportation phase of the industry. The mortality was attributed to the bacterium *Vibrio harveyi*, which occurs naturally in the marine environment, including the water column, in sediments and in the guts of marine animals. The mortality occurred after transportation of the pearl oysters from collection areas to the lease sites. Instead of the usual 10% to 20% mortality, losses on lease sites were up to 80%. Surviving pearl oysters developed deformed nacre and were useless for half pearl or mother of pearl production. Poor water circulation and accumulations of mollusc faeces on the bottoms of the tanks in which the oysters were transported were found to allow the number of bacteria to increase exponentially during transport. The possibility was also raised that circulation was not as effective on culture rafts as on long lines, and bacterial densities were higher. Whereas other infectious agents or causative factors could have been involved, it was concluded that pearl oysters were weakened during the low temperatures of winter, and they became infected when they came into contact with high bacterial concentrations (Wolf & Sprague 1978, Pass & Perkins 1985, Dybdahl & Pass 1985, Pass et al. 1987, 1988).

The mortality experience has made the pearling industry operators acutely aware that they are dealing with live animals that must be treated properly if high quality pearl production is to be achieved. A number of changes were made to improve treatment of the animals. The various processes are now staged to allow the animals to recover from each procedure (collection, transportation, seed implantation, etc.) before the next stage is attempted. Water circulation during transportation has been improved considerably, and the water in tanks is now exchanged about every 10 min. High-density raft culture has ceased and been replaced with long line techniques that use a lower stocking density.”

The present day translocation management strategy reflects the importance of disease mitigation, in particular, to the pearling industry. Translocation of *P. maxima* is regulated under the PA and the PR and the FRMR (Part 13A only). Reflecting this legislation, the Pearl Oyster Translocation Protocol provides further guidelines on the translocation of pearl oysters. The protocol includes guidance on:

- The movement of hatchery-produced pearl oysters;
- The movement of all pearl oysters between farm leases¹;
- The reporting of hatchery-settled pearl oyster spat (via a *Pearl Oyster Settlement Form P9*);
- The requirements for spat leaving a hatchery and the testing of hatchery spat by an approved fish pathologist;
- The requirements for pearl oyster spat transported from a hatchery to a farm lease site (including submission of required log sheets);
- The translocation and handling procedures when unusually high mortality levels indicate there may be a disease risk;
- The requirements and procedures for health testing and the destruction of pearl oyster spat that has failed health testing; and
- The minimum standards required for hatchery accreditation, including the cleaning/disinfecting schedule and the disinfection of hatcheries when a batch fails health certification.

This Protocol primarily governs the movement of hatchery-produced pearl oysters and the movement of oysters between farms. The *Pearl Oyster Translocation Protocol* is not a statutory document it does reflect the legislated requirements (within the PA, PR and FRMA) and there is a high level of compliance with the recommended procedures, as any deviation may delay or cause the refusal of translocation approvals by the Department.

14.2 Pearling industry impacts

14.2.1 Risk assessment outcomes

The impact of translocation has been assessed using a risk based approach (see Section 2.5). The results and justifications of the most recent risk assessment are provided below.

14.2.1.1 Translocation of pearl oysters

2015 ERA Risk Rating: Impact of translocation on genetic structure of silver-lipped pearl oysters populations (C1, L1 Negligible)

2015 ERA Risk Rating: Impact of translocation on transfer of diseases between silver-lipped pearl oyster populations (C3, L2 Low)

¹ Note the *Pearl Oyster Translocation Protocol* does not apply to the initial movement of wildstock pearl oysters sourced from the fishing beds within WA to a dump site/holding site within WA.

The PA, PR and FRMR (part 13A) have sections that regulate the movement of pearl oysters in WA, with the *Pearl Oyster Translocation Protocol* providing guidance on this legislation and translocation that is adhered to by the pearling industry (see Section 14.3 and Appendix A). This includes when a health certificate is required.

There is also a passive surveillance program undertaken by the Department and an incident management protocol. The pearling industry has also developed a *Pearling Environmental Code of Conduct*, which outlines the environmental responsibilities of license holders (see Section 2.4.2.1). This Code of Conduct includes general practices for disease management (e.g. water quality management, hygiene and post seeding/harvest health).

Studies undertaken by Johnson & Joll (1983) and by Benzie & Smith-Keune (2006) found WA and NT populations of *P. maxima* to be genetically different. Thus, despite substantial historical translocation of *P. maxima* from WA into NT, the regional population structure has been maintained (i.e. is not genetically homogenous), suggesting that pearl culturing has had minimal (if any) genetic impacts on wild stocks. A study on the impacts of cultured stock on the genetic structure of wild black-lipped pearl oyster (*P. margaritifera*) populations showed no impact of extensive pearl farming on the genetic structure of wild populations (Arnaud-Haond et al. 2003).

All pearl oyster shells collected from the wild are cleaned at the fishing area prior to being moved to dump or holding sites. This practice helps to prevent the spread of diseases or pests between fishing and holding areas. There have been minor problems with the introduction and transfer of diseases in the past; however, since the 1970's the only known disease is the spread of OOD in the Exmouth Gulf (Zone 1). This is thought to have occurred partly due to the boat movements, indicating that the disease was likely to be transferred between areas via boats or diving equipment. There is an ongoing research program in place which includes efforts to identify and develop tools to better understand the pathology and cause of OOD in pearl oysters. This information will help to inform disease protocols in the future. The FRDC project "Pearl Oyster (*Pinctada maxima*) Aquaculture: Health Survey of Northern Territory, Western Australia and Queensland Pearl Oyster Beds and Farms" (Humphrey et al. 1998) showed that there was no difference in the health status of NT and WA oyster beds and farms. Continued pre-movement testing of pearl oysters from both jurisdictions supports these findings.

While pearl oyster diseases may have significant impacts at the farm level, the regulation and policies in place limit the likelihood of industry-wide impacts occurring.

14.3 Management strategy

There is a strategy in place for managing the impacts of translocation on the surrounding ecosystem. Translocation is regulated by the following legislative instruments and associated management measures:

- *Pearling Act 1990* and *Pearling (General) Regulations 1991*:

- Structure of the pearling industry (licences and farm leases etc. granted under the PA);
- Restrictions are imposed on the transport of *P. maxima* (Part 7 of the PR details transportation procedures and approvals required); and
- Requirement for transport log sheets (Regulation 16 of the PA).
- *Fish Resources Management Regulations 1995*:
 - Transport is regulated out of a hatchery, off a quarantine site and out of a zone of the fishery unless a certificate of health is in force and transported in accordance with approval of transport (Reg. 144G)¹; and
 - Transport into the state of pearl oysters that are not of WA origin requires the approval of the CEO of the Department.

The *Pearl Oyster Translocation Protocol* is utilised in decision making relating to pearl oyster transport approvals. There is also a MoU between the WA and NT governments, in which states agree to develop consistent translocation and health protocols.

Transports of pearl oysters require application by the pearling company for approval from a pearling inspector (P2 form - Notice of Pearling or Hatchery activity), this may include a requirement for a health certificate. Significant quantities of pearl oyster samples (as specified in the *Pearl Oyster Translocation Protocol* and Regulation 144C of the FRMR for spat only) are to be submitted to the government fish health division for a certificate of health to be issued. This approval will be denied if there were disease concerns about particular pearl oysters, a farm lease, hatchery or area.

The Department maintains a passive surveillance program in this sector, actively investigating reports of abnormal mortalities, which are backed up by emergency response capability in the areas of both aquatic pests and diseases. An ongoing research program includes efforts to identify and develop tools to identify the cause of oyster oedema disease in pearl oysters.

The *Pearl Oyster Translocation Protocol* discusses what would occur if any signs of disease were found in the health certificate procedure. This reflects legislative requirements that may include destruction, quarantine or further testing of the batch on the infected site. If a health certificate cannot be issued, the batch is destroyed; this procedure is outlined in the Protocol.

Any unusually high mortality levels that occur during the translocation of pearl oysters must be reported to the Department (senior fish pathologist and CEO). Additionally, there are procedures to follow when disinfecting a hatchery site, there may also be additional directions provided by a pearling inspector (if supervising this procedure).

A Departmental incident response manual has been developed, which details protocol associated with emergency biosecurity response. The Department is equipped with state-of-

¹ Note the Department is currently reviewing this section of the Regulations to ensure it reflects the repealed *Stock (Disease) Regulations Act 1968* and *Enzootic Diseases Regulations 1970*.

the-art diagnostic laboratories and capability. It participates in nationally-coordinated proficiency testing programs and is accredited to ISO17025 for both pest identification and pathogen identification.

While no nationally agreed response plans (Aquavetplans) have been identified of immediate relevance to known threats to pearl oysters in WA, a general response manual exists which would be followed in incidences of pest or disease emergence. Simulated disease response exercises have also been conducted at the State level.

14.4 Information and monitoring

The FRMR (Schedule 14, Form 8) and the *Pearl Oyster Translocation Protocol* has a declaration that companies fill out regarding mortality and disease of pearl oysters, which is to be submitted to the approved pathologist. Companies are also required to provide notification of the movement of pearl oyster (P2 form to be filled in and submitted to the Broome office), a health certificate if required and a transport log sheet to be completed following completion of the transport.

Given the notification that the Department received via the P2 form (*Notice of Pearling or Hatchery Activity*), it maintains a database of approved transports by the pearling industry. This can be used to audit movements of pearl oysters if required in the event of a disease incident.

MSC Principle 3

The pre-assessment report for the pearling industry confirmed that it meets the scope criteria for an enhanced fishery with both a catch-and-grow (CAG) and a hatch-and-catch (HAC) component. The HAC component is not part of the current MSC assessment. There are no modifications to the Principle 3 requirements of the default tree structure in enhanced bivalve fishery assessments.

15. Governance and policy

This section captures the broad, high-level context of the management system within which the pearling industry operates. It includes:

- The legal and customary framework, including national environmental legislation, jurisdictional arrangements between the state of WA and the Commonwealth government and the system of governance in WA, including relevant pearling legislation;
- Consultation processes and policies, as well as an articulation of the roles and responsibilities of people and organisations within the overarching fishery management system; and
- The long-term fishery management objectives.

15.1 Legal and/or customary framework

The management system for pearling activities exists within an appropriate and effective legal framework, which ensures that it (1) is capable of delivering sustainability in the UoA(s) that are consistent with MSC principles 1 and 2; (2) observes the legal rights created explicitly or established by custom of people dependent on fishing for food or livelihood; and (3) incorporates an appropriate dispute resolution framework. The POF and its cultivation requirements are purely domestic, managed on a regional scale across two States of Australia, being Western Australia and the Northern Territory.

15.1.1 National and State legislative framework

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 *Environment Protection and Biodiversity Conservation Act 1999* (EPBC), which is administered by the DotE. The EPBC provides a legal framework for the protection and management of nationally- and internationally-important flora, fauna, ecological communities and heritage places — defined in the EPBC as ‘matters of national environmental significance’.

There are three 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).

At the Commonwealth level, responsibility for managing fisheries resources lies with the Australian Department of Agriculture, Fisheries and Forestry under the powers of the Australian *Fisheries Administration Act 1991* and the *Fisheries Management Act 1991* (FMA). AFMA administers this legislation when managing the fisheries they are responsible for in Commonwealth waters.

Management responsibilities of all State or coastal waters (out to 3 nm) and most of the Western Australian fisheries resources within the Australian Fishing Zone (AFZ) (out to 200 nm which is inclusive of all Commonwealth waters) is vested in the Western Australian Government in accordance with the objects and provisions of the FRMA, the PA and a formal agreement between the Commonwealth and State Governments called the *Offshore Constitutional Settlement 1995* (OCS)¹. The OCS is given effect by arrangements made under Part 3 of the FRMA and Part 5 of the FMA.

The State of Western Australia is an autonomous regional government that is a member of the Federation of Australian States that forms the Commonwealth of Australia. The Commonwealth and its member States base their legal and political frameworks on the Westminster system of government, which separates the legislature, executive and judiciary into independent arms of government. The Minister for Fisheries (Minister) is appointed to the Executive Council by the Governor of Western Australia and has primary responsibility on behalf of executive government for the administration of the PA and FRMA, while the CEO of the Department of Fisheries has specific functions under the PA and FRMA.

The Minister / Department are responsible for the sustainable development and management of the State's aquatic resources, fisheries, pearling and aquaculture in accordance with its governing legislation. The Department is established under Section 35 of the *Public Sector Management Act 1994* and is required to provide an *Annual Report*² to Parliament in accordance with the requirements of the *Financial Management Act 2006*, the FRMA and the Public Sector Commission's *Annual reporting framework*. The Annual Report provides a comprehensive overview of the Department, its operations and its performance.

The Department provides management, licensing (where applicable), research, 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 2016-2020*, which sets out explicit long-term objectives in three main areas: community and stakeholder benefits, sustainability, and management excellence.

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

¹ http://www.fish.wa.gov.au/Documents/management_papers/fmp077.pdf

² The most recent annual report is available on the Department's website at: <http://www.fish.wa.gov.au/About-Us/Publications/Pages/Annual-Report.aspx>

- **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.

Further information on the Department's structure, management, research, compliance and other activities is available in the *Annual Report*¹ and the annual companion publication *Status Reports of the Fisheries and Aquatic Resources of Western Australia: state of the fisheries*².

15.1.2 Relevant fisheries legislation

The PA and PR, together with MPG 8 and 17 (issued pursuant to the PA) are the primary instruments for management of the pearling industry in WA. The PA provides for the creation of subsidiary legislation, in the form of Regulations, Notices, MPGs and leases and licences (with conditions). To ensure a sustainable fishery, this legislation clearly defines where and how many pearl oysters can be taken from the wild population, who may commercially take pearl oyster and the size limits that apply. For cultivation purposes, MPG 17 provides guidelines on the location and size of pearl oyster farm leases and holding sites.

In 2010, the (then) Minister for Fisheries directed the Department to review the existing legislation 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. As a result the Aquatic Resource Management Act (ARMA; currently before parliament as the *Aquatic Resource Management Bill 2015*³) was drafted and provides an innovative legislative and administrative framework for the future management of the State's fish and aquatic resources, based on the principles of Ecologically Sustainable Development and Ecosystem Based Fisheries Management.

Its main features include a shift in focus from the management of individual commercial fisheries to the management of aquatic resources that places ongoing sustainability at the fore of management considerations. It provides for transparent and defined allocations of the total allowable catch between the commercial and recreational sectors after setting aside the quantity of the resource required for sustainability and public benefit purposes such as fisheries research, and customary fishing. It also includes the capacity to make sectoral

¹ <http://www.fish.wa.gov.au/About-Us/Publications/Pages/Annual-Report.aspx>

² <http://www.fish.wa.gov.au/About-Us/Publications/Pages/State-of-the-Fisheries-report.aspx>

³ The Bill can be viewed on the Parliamentary website
<http://www.parliament.wa.gov.au/parliament/bills.nsf/BillProgressPopup?openForm&ParentUNID=1D103914B411A4CF48257DF6001BBD6B>

management plans or Aquatic Resource Use Plans (ARUPs) which will contain the sectoral rules for fishing the resource.

The ARMA also includes enhanced powers to manage disease and other biosecurity risks in the aquatic environment. In most other respects the Bill contains similar provisions to those that already exist in the FRMA.

Ultimately the legislation will result in the repeal of the FRMA and the PA. However even after the repeal of the FRMA, management plans for managed fisheries will continue in force and may be amended from time to time, until such time as the resource is declared and an Aquatic Resource Management Strategy (or ARMS) and ARUPs are made for that resource (or relevant group of resources).

The PA will continue to be in force and pearling will continue to be managed under its provisions until it is repealed.

15.1.3 Management framework

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)¹. This policy provides high-level guidance on the Government's preferred approaches to key resource management challenges, including resource management, resource access and allocation, marine planning and governance and consultative structures. The Government has also recognised that more-detailed policies are needed for other key areas. These complimentary policies include:

- *Harvest Strategy Policy for the Aquatic Resources of Western Australia* (DoF 2015)²
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* (DoF In prep). This overarching policy 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).

15.1.3.1 Ecologically sustainable development

In accordance with international treaties and initiatives, the Australian Government is committed to implementing the principles of Ecologically Sustainable Development (ESD).

¹ http://www.fish.wa.gov.au/Documents/corporate_publications/wa_govt_fisheries_policy_statement.pdf

² http://www.fish.wa.gov.au/Documents/management_papers/fmp271.pdf

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 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 assessment¹ of a fishery in accordance with the EPBC is required for export to occur (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 (Guidelines; CoA 2007)*, with their ongoing performance reported annually in the *Status Reports of the Fisheries and Aquatic Resources of Western Australia: state of the fisheries* (e.g. Fletcher and Santoro 2014).

15.1.3.2 Ecosystem based fisheries management

The Department has implemented Ecosystem Based Fisheries Management (EBFM) as the primary strategy to achieve the goal of ESD for fisheries. 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 Fisheries Research and Development Corporation (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; Fletcher 2012) to establish priorities, allowing the Department to focus on managing resources most at risk and

¹ Further information on fishery assessments against the EPBC is provided on the DotE website at: <http://www.environment.gov.au/marine/fisheries>

of the most value to the community. It also complements Integrated Fisheries Management (IFM), which allocates a percentage of the catch to sectors (commercial and recreational) 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 identified for each bioregion¹. The risks associated with each individual ecological asset are examined separately using formal qualitative risk assessment (consequence x 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 then 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 15.1) 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 15.1). 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*² 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. Thus, 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 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.

¹ 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*.

² <http://www.fish.wa.gov.au/About-Us/Publications/Pages/Annual-Report.aspx>

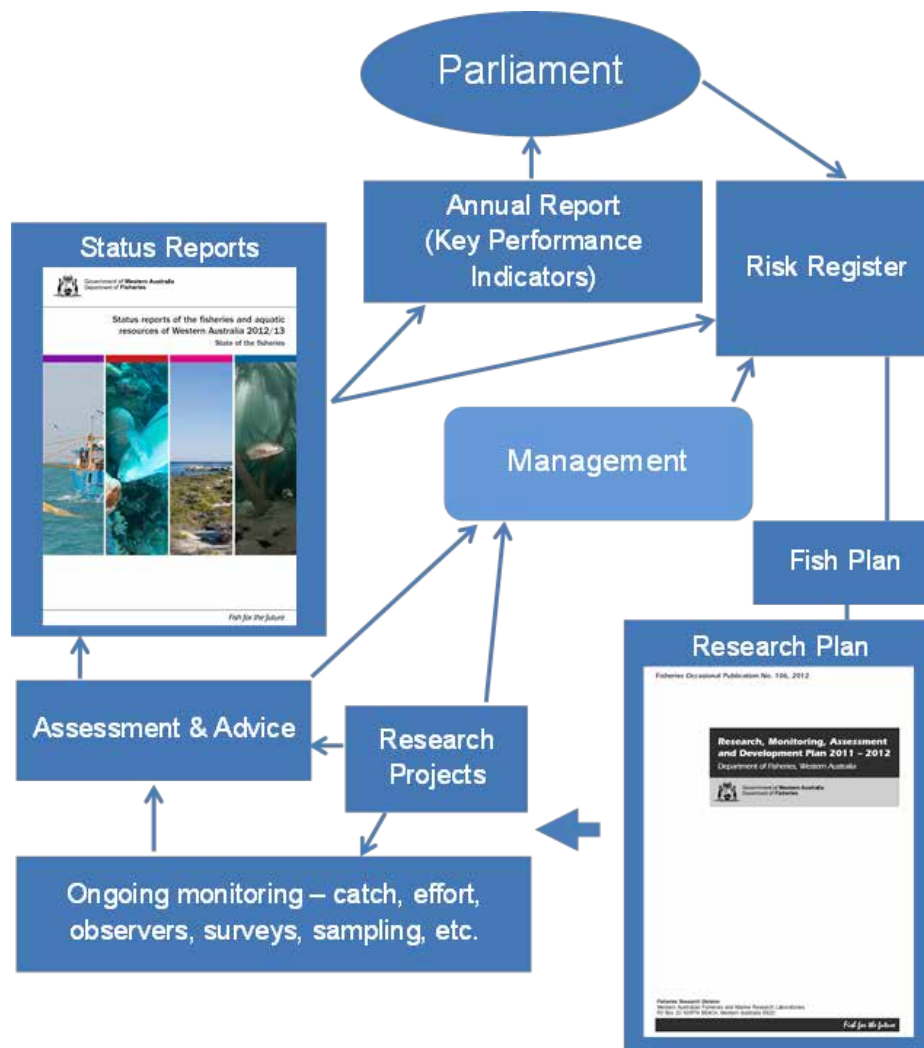


Figure 15.1. Outline of risk-based planning cycle used by the Department to determine annual priorities and activities.

15.1.3.3 Catch allocation

Historically, WA's fish resources have been shared on an implicit basis, with no explicit setting of catch shares within an overall total allowable catch (TAC) or corresponding total allowable effort (TAE). In more recent years, the Department has begun implementing an IFM approach, where the aggregate effects of all fishing sectors are taken into account. This involves the use of a framework in which decisions on optimum resource use (i.e. allocation and re-allocation of fish resources) are determined and implemented within a total sustainable catch for each fishery or resource.

The IFM process will generate explicit allocations and / or re-allocations to specific sectors using a formal and structured allocation process facilitated by an independent body – the Integrated Fisheries Advisory Allocation Committee (IFAAC). This process has already been completed for western rock lobster, metropolitan abalone fisheries and the West Coast Demersal Scalefish Fishery.

The IFM framework, including the need for explicit catch shares to strengthen access rights, will be further strengthened with the introduction of the ARMA. In essence, the IFM approach involves:

- Setting a total allowable harvest level of each resource that allows for an ecologically-sustainable level of fishing;
- Allocation of explicit proportional catch shares for use by the commercial and recreational sectors (after taking into account customary fishing);
- Continual monitoring of each sector's catch;
- Managing each sector within its allocated catch share; and
- Developing mechanisms to enable the reallocation of catch shares between sectors.

15.1.4 Memorandums of Understanding (MoUs)

Particularly in cases where cross jurisdictional issues arise, MoUs have been developed to ensure consistent application of management measures in order to meet objectives. For example, there is an MoU between the Minister for Fisheries Western Australian Government and the Minister for Primary Industry and Fisheries Northern Territory Government regarding the management of the *Pinctada maxima* Australian South Sea Pearl industry. This MoU aims to:

- ensure that consistent standards of management (i.e. translocation and fish health protocols) and compliance exist within the Australian South Sea pearling industry in WA and NT; and,
- ensure that efficiencies and synergies in pearling management and compliance are achieved through cooperative arrangements.

Similarly, there is an Accord between the PPA and the Kimberley Marine Tourism Association relating to the location of pearl farm leases and charter boat operations. In essence, the Accord states that all waters are open to pearl oyster farm leases other than waters prescribed in the Accord that are regularly used by charter boat operators. The Department is to have due regard for the Accord when dealing with farm lease applications.

15.1.5 Resourcing the management process

From July 2010, managed commercial fisheries have been subject to a new annual access fee model. The new access fee 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 managed commercial fisheries in WA paying an access fee equivalent to 5.75 % of the gross value of production (GVP) of the respective fishery. The POF is subject to the above-mentioned annual access fee model. Additionally, pearl oyster seeding (wildstock and hatchery) is regulated in Western Australia and an annual fee is imposed that reflects the management and compliance costs to Government. An annual fee is also imposed for a hatchery licence. Pearl oyster farm lease holders are also charged an annual fee per square nautical mile for each farm lease held.

15.1.6 Resolution of disputes

Disputes are proactively minimised through the educative role carried out by Fisheries and Marine Officers and other Departmental staff, and through consultation with WAFIC and the PPA when required. Where necessary, administrative and legal disputes in relation to fisheries are resolved through the WA State Administrative Tribunal (SAT) or WA court system. Dispute resolution for administrative decisions made under the PA is provided for in Part 4 of the PA through appeal to the SAT. Criminal offences are dealt with by the Magistrates Courts. Decisions of the SAT and the Courts are binding for the Department.

This formal mechanism for resolution of disputes has been tried and tested across many fisheries. An example of a decision following a dispute in the non-maxima pearl industry can be found in these case notes¹.

With regard to the grant of authorisations under section 23 of the PA, there is a statutory requirement to advertise particular decisions as well as the right of an aggrieved person to appeal the decision through the SAT.

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.

15.1.7 Respect for rights

Commonwealth legislation, the *Native Title Act 1993* (NT Act), provides the means by which the Australian legal system recognises the traditional rights and interests of Aboriginal and Torres Strait Islander people. This ensures access to fish and shellfish resources for people who depend on fishing for their food.

The Federal Court of Australia has recognised non-exclusive Aboriginal rights in relation to waters, including sea, as including the right to fish and use the resources of the waters for personal, domestic and communal needs (including, but not limited to, cultural or spiritual needs) but not for commercial purposes in its Agreements. It went further in *Hunter v State of Western Australia* (2009)² when it set out the specific nature and extent of native title rights and interests in relation to *P. maxima*. These were:

- (a) “The right to take live adult *P. maxima* for the purpose of:
 - (i) Sustenance; and
 - (ii) Using its shell for the ceremonial activities of the Nyangumarta people, including the ceremonial exchange of goods (including items made from *P. maxima* shell), to the extent that such exchange is effected in accordance with a traditional ceremony.

¹ [http://decisions.justice.wa.gov.au/SAT/SATdcsn.nsf/PDFJudgments-WebVw/2006WASAT0018/\\$FILE/2006WASAT0018.pdf](http://decisions.justice.wa.gov.au/SAT/SATdcsn.nsf/PDFJudgments-WebVw/2006WASAT0018/$FILE/2006WASAT0018.pdf)

² <http://www.austlii.edu.au/au/cases/cth/FCA/2009/654.html>

- (b) The right to take shell of dead *P. maxima* for the purpose of using its shell for the ceremonial activities of the Nyangumarta people including shell of live or dead *P. maxima* shell), to the extent that such exchange is effected in accordance with a traditional ceremony.

Provided that the native title rights and interests to take adult *P. maxima* (including shell of live or dead *P. maxima*):

- (c) Does not include the taking of it while using artificial breathing apparatus, such as but not limited to scuba or hookah apparatus (surface supplied compressed air) but not including apparatus such as snorkels;
- (d) For the avoidance of doubt, do not include any right to use *P. maxima* (including shell of live or dead *P. maxima*) for sale, barter or exchange, other than exchanges made in accordance with traditional ceremonies confirming with (a) or (b) above.”

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 Australia 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.¹ 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 to fish is being exercised by an Aboriginal person for a traditional, non-commercial purpose.

A key aspect of the NT legislation is that proposed developments or activities (including fisheries where a registered claim or determination extends into State waters) that may affect native title are classed as ‘future acts’. In 1999, the Department obtained a ‘Report for Fisheries Western Australia’ in respect to the interaction between fisheries / pearling legislation and the NT Act. The report advised that:

1. The very wide scope of what can be done under a fishery management plan means that fisheries / pearling do have the potential to affect native title. As a result, a new management plan would be considered a ‘future act’ for the purpose of the NT Act.
2. Because a new management plan would be covered by section 24 HA of the NT Act, it can be validly made without the need for any specific native title notification or comment procedure.
3. While specific notification is not required, it would, however, be prudent for comment to be sought from any native title parties likely to be affected by the new management plan under the provisions of the FRMA section 64(2).
4. The granting of licences and permits under management plans will not be ‘future acts’ in their own right, and they can therefore be granted without the need for any native title procedure or notification requirement.

¹ <http://www.hcourt.gov.au/assets/publications/judgment-summaries/2013/hca47-2013-11-06.pdf>

In accordance with point 3 above, the Department provides any native title party or parties with an opportunity to comment on the development of a proposed fishery.

The Native Title Tribunal facilitates the negotiation of indigenous land use agreements following a claim¹ or determination² and is required to keep registers of approved native title claims and determinations. There are a number of native title determinations and applications along the Western Australian coast that include marine waters that overlap with pearl fishing grounds and pearl farms although this does not impact native title rights. A map of all WA determinations and applications can be viewed from the National Native Title Tribunal website at http://www.nntt.gov.au/Maps/WA_NTDA_Schedule.pdf

15.1.8 Customary fishing in WA

Customary fishing is legislated under the FRMA and means “*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.*” The rights of Aboriginal persons to fish for a customary purpose are recognized in the FRMA which provides that “*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*”. Section 258 (1) (ba) of the FRMA allows for customary fishing to be regulated.

The Department released a *Customary Fishing Policy* position statement in 2009³, 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.”*

This policy statement explicitly states that “Customary fishing is to be articulated and clearly separated from other forms of fishing in fisheries legislation and policy to allow for the development of appropriate management arrangements that reflect customary fishing access rights, practices and sustainability requirements.”

Under the proposed ARMA, a quantity of each specified aquatic resource will be reserved for conservation and reproductive purposes, with a sustainable allowable harvest level set for use by the fishing sectors. The quantity ‘reserved’ includes an allowance for customary fishing and public benefit purposes, such as scientific research. Thus, a specific share does not have

¹ A registered native title claim is an application where a decision about native title is yet to be made.

² A determination of native title is a decision that native title does or does not exist in a particular area of land and/or waters (the determination area).

³ http://www.fish.wa.gov.au/Documents/customary_fishing/customary_fishing_policy.pdf

to be allocated to the customary sector, as that share is set aside prior to setting an allowable harvest level for the resource. In this way, customary fishing can continue in accordance with existing customary fishing arrangements. IFM also recognises the rights of customary fishers of Aboriginal descent who are fishing for cultural needs. The ARMA will further strengthen the statutory basis for customary fishing rights as part of an overall strengthening of the rights framework.

Many of the pearl oyster farm leases are adjacent to Aboriginal lands. Farm leases are non-exclusive, meaning that there is no impediment to traditional, recreational or commercial vessels traversing the farm lease, or to traditional, commercial or recreational fishers utilising natural resources (apart from *P. maxima*) within a farm lease area. In addition, MPG8 explicitly requires that the Aboriginal Affairs Department, native title holders and claimants or their legal representative, the relevant Aboriginal Land Council or relevant Aboriginal body and the Aboriginal Legal Services are consulted with prior to the initial grant of a farm lease.

The Department has no record of the amount of *P. maxima* caught for customary purposes.

15.2 Consultation, roles and responsibilities

The WA Government's commitment to consultation and engagement in fisheries management is set out in the *Western Australian Government's Fisheries Policy Statement* of 2012. The Department's responsibilities and identified stakeholders are outlined in the *Annual Report*. Stakeholders include the community of WA, peak commercial and recreational sector bodies, industry associations, all fishers, fish processors, fisheries volunteers, environmental groups, businesses and communities directly and indirectly dependent upon fishing and aquaculture activities, the offshore oil and gas sector and other state, national and international government agencies and tertiary institutions.

15.2.1 Roles and responsibilities

The roles and responsibilities of organisations (e.g. WAFIC) and individuals (e.g. the Minister) who are involved in the management process are well understood with key powers explicitly defined in legislation (e.g. FRMA and PA) or relevant policy statements and agreements.

15.2.1.1 Department of Fisheries

The roles and responsibilities of the State of WA in fisheries management is explicitly outlined in the *Western Australian Government Fisheries Policy Statement (March 2012)*, the *Annual Report* 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 peak bodies for the commercial (WAFIC) and recreational sectors (RecFishWest [RFW]) in WA.

Key Departmental personnel to whom the responsibilities of ensuring management, research and compliance outcomes (including proper prioritisation of departmental funding) for the pearling industry include:

- Northern Bioregion Program Manager (Aquatic Management Division);

- Northern Bioregion Fisheries Management Officers (Aquatic Management Division)
- Supervising Scientist —Invertebrates (Research Division);
- Senior Research Scientist —Molluscs (Research Division);
- Compliance Manager North (Regional Services Division);
- Regional Manager North (Regional Services Division); and,
- Fisheries and Marine Officers in Broome are Pearling Inspectors for the purposes of the PA (Regional Services Division).

The Minister / Department is responsible for advising licence holders (as well as the PPA) and WAFIC of Ministerial / Departmental decisions that are the subject of a consultation process. Responsibilities of the Department in formal consultation arrangements with WAFIC are that the Department —

- Provides annual funding to WAFIC equivalent to 0.5 % of WA commercial fishing gross value of product (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;
- Engages with WAFIC, sector bodies and commercial fishing interests according to WAFIC's Operational Principles (see Section 15.2.1.2.1 below).

The Department is also responsible for ensuring the recreational fishing sector, through RFW, is formally consulted on proposed changes to recreational fisheries management and is advised of Ministerial / Departmental decisions that are the subject of a consultation process. The Department is responsible for providing RFW 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.

15.2.1.2 Peak sector bodies

The WA Government formally recognises WAFIC and RFW as the key sources of coordinated industry advice for the commercial and recreational sectors, respectively.

15.2.1.2.1 Western Australian Fishing Industry Council

WAFIC¹ 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 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;

¹ More information about WAFIC is available on their website: www.wafic.org.au/

- 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 (provided under a funding agreement) for industry representation and taking on a leadership role for matters that 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 for self-representation.

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;
- 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 RFW and other appropriate parties with a view to identifying joint priorities and solutions to issues of shared concern;
- 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 responsibilities for consultation services are clearly outlined in a Service Level Agreement (SLA) with the Department.

15.2.1.2.2 RecFishWest (RFW)

RFW¹ is the peak body for the recreational sector and, in accordance with the Service Level Agreement between RFW and the Department, RFW has the responsibility to provide representation of recreational fishing interests in Western Australia and their key deliverables include:

- Provide recreational fishing representation, consultation and engagement;

¹ More information about RFW is available on their website: www.recfishwest.org.au/

- Provide peak body advice;
- Promote key sustainability messages; and,
- Project management.

RFW receives 15 % of the revenue raised from recreational fishing licence fees to provide the above deliverables.

A recent example of extensive consultation processes undertaken by RFW was in relation to the proposed reform of statewide recreational fishing rules in 2012 as outlined in Fisheries Management Paper 252¹. RFW completed a consultation report (which is available on request) which summarized the process. The consultation included visiting regional locations such as Albany, Broome, Carnarvon, Denham, Derby, Esperance, Exmouth and Karratha, as well as holding information sessions at several metropolitan locations. RFW conducted an online survey and produced a “Have your say” document as methods to receive comments. RFW received a total of 996 submissions, 850 of which were from the online survey.

In early 2014 RFW again surveyed recreational fishers about how changes to fishing rules implemented in February 2013 have affected their recreational fishing experiences. RFW received 943 responses to this survey from a range of regions that closely resembles the distribution of Recreational Fishing from Boat Licence (RFBL) holders throughout the state.

Using the results of this survey and the comments provided, RFW concluded that the majority of the rules implemented in 2013 has had a positive effect on fishing experiences, and that 90% of fishers have found it beneficial to have a single consolidated guide book covering the whole of Western Australia. These results support the Department’s strategy to pursue a simplification of the recreational fishing rules. RFW provides summaries of the survey results to the Department.

15.2.1.3 Licensees / sector associations

Fishery licence holders have a responsibility to make themselves aware of the fisheries legislation that relates to their activities as it changes from time to time. In order to fulfil this responsibility, the Department assists pearling industry licence holders by explicitly reminding them in writing of where they can access the latest legislation. The following information can be found on every licence (e.g. Pearl Oyster Hatchery (Nursery) Licence, Pearl Oyster Pearling (Seeding Licence) (“Hatchery Quota”), Pearl Oyster Pearling (Wildstock) Licence) *“Fisheries legislation changes from time to time. To assist fishers, aquaculturists and members of the public to access fisheries legislation, the Chief Executive Officer has arranged for up to date fisheries legislation to be made available on the internet. Fisheries legislation may be viewed by logging on to the Department of fisheries website (www.fish.wa.gov.au) and clicking on the Legislation link on the top of the home page. The Chief Executive Officer recommends that the licence holders and persons acting on their behalf (e.g. employees), regularly access this legislation service and make themselves aware of the fisheries legislation that relates to their activities.”* (see Appendix C).

¹ http://www.fish.wa.gov.au/Documents/management_papers/fmp252.pdf

Licence holders operating in the pearling industry have a number of responsibilities including completion of a number of logsheets to ensure that all of the relevant data and information is collected. These logsheets include:

- Annual Notice of Intent
- Notice of Pearling or Hatchery Activity
- Pearl oyster fishing daily logsheet
- Divers catch logsheet
- Dump record log sheet
- Transport log sheet
- Transport (seeding) logsheet
- Pearl seeding logsheet
- Pearl oyster tag log sheet
- Notice of settlement of spat
- Nursery site stock report

The PPA was formed in 1988 and is the peak representative body for the pearling industry in WA. The PPA is also the primary source of contact between the Department and Industry (although formal contact is via the Industry Consultation Unit at WAFIC, as established under the SLA). The PPA plays a major role in ensuring the sustainability of the pearling industry through its commitment to the continuing implementation of industry best practice based on ecologically sustainable development principles (see Pearling in Perspective - Environmental Code of Conduct, PPA 2008a). The PPA represents and supports its members across a range of issues, preparing industry wide contribution to regulatory developments and research, both directly through submissions as well as representing all members at Departmental, ministerial and community levels when required. The PPA also plays a role in diver health and safety and has produced a pearl diving industry code of practice (PPA, 2012).

15.2.2 Consultation processes

The WA Government's commitment to consultation with stakeholders is set out in the *WA Government's Fisheries Policy Statement*. The broad consultation framework (Figure 15.3) was developed following the outcome of a 2009 review of consultation arrangements between the fishing sector and Government, which resulted in:

- Recognition of WAFIC as the peak body representing the commercial fishing sector (including pearling and aquaculture) and RFW as the peak body representing the recreational fishing sector, with funding provided by Government to each peak body to support these roles;
- Capacity for these peak bodies to perform consultation functions on behalf of the Minister. In this regard, the Department has entered into a SLA with WAFIC for the provision of specified, mostly statutory, consultation services with the commercial sector;
- 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 RFW, 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 from 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 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 and determining catch shares among sectors.

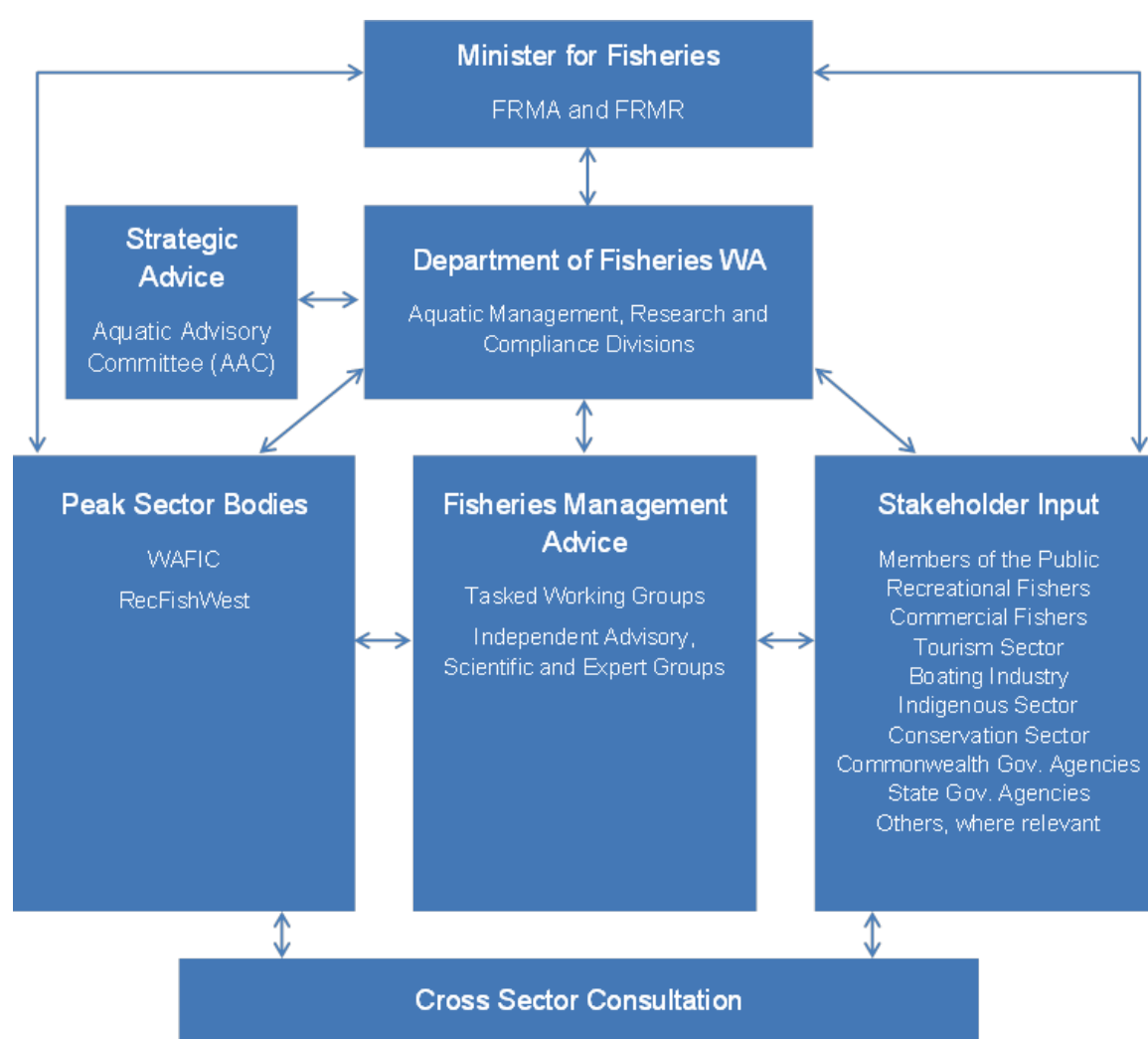


Figure 15.3. Broad fisheries management consultation framework in WA

Consultation protocols between the Department and WAFIC and RFW have also been developed to provide operational guidance for consultation processes pursuant to the representation and consultation roles outlined in the Funding Agreement between the Department and the two peak bodies.

15.2.2.1 ARMA consultation

A significant difference of the proposed ARMA is a shift in focus to explicitly involve the public and interests of different sectors in decisions about the management and conservation of aquatic resources and ecosystems. This new legislation will strengthen the Department's performance against this scoring issue. Specifically, the ARMA requires a public notice of a draft ARMS inviting interested persons to make a submission on the draft strategy. The ARMS must also specify the consultation to be carried out in relation to the making, amending or revoking of an ARUP.

15.2.2.2 Statutory consultation

MPG No. 8¹ (issued pursuant to section 24 of the PA) sets out the Minister's preferred approach to the assessment and community consultation procedure which is to be followed when considering pearl oyster farm lease applications in coastal waters in WA. The decision making authorities, other involved agencies, representative community and interest groups are identified in MPG 8 and are to be engaged with as part of the consultation process.

Under the proposed ARMA, the *P. maxima* resource will be required to have an ARMS and statutory consultation will be required under the ARMA. The development of the ARUP will also require consultation which will be specified in the ARMS.

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

15.2.2.3.1 Strategic advice

An AAC provides independent advice to the Minister / Department on high-level strategic matters. This committee consists of members who have strong backgrounds in governance and policy.

15.2.2.3.2 Fisheries management advice

Fisheries management advice may be provided by tasked working groups and / or independent advisory, scientific and expert groups. Tasked working groups and panels can be established by the Director General of the Department (also referred to as the CEO) or the Minister to provide independent, expert advice relating to a range of fisheries management matters. Working groups are highly flexible and work to specific terms of reference within a particular timeframe. They are usually provided with a specified task, such as addressing resource access (e.g. closures and compensation) and allocation (e.g. IFM) or reviewing research, management or Government policy.

¹ http://www.fish.wa.gov.au/Documents/ministerial_policy_guidelines/fmpg008.pdf

For high level overarching key policy development such as the recent finalisation of the Fisheries Management Paper No. 271 “Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia”, more targeted expert based input is sought (DoF 2015). The draft harvest strategy policy was sent to the Australian Fisheries Management Authority and the Australian Fisheries Management Forum (who developed the National Fishery Harvest Strategy Guidelines) for input, in addition to WAFIC and RFW (who reviewed the draft policy twice). Verbal briefings were also provided if requested. In this case, WAFIC commissioned a consulting company to undertake a review of the draft policy and subsequently provided the review report to the Department with advice that it supported the review outcomes. Various changes were made to the policy to accommodate the comments received. WAFIC and RFW then provided written advice that they had no final comments on the final version.

15.2.2.3.3 Stakeholder input

The Department / Minister is responsible for advising licensees and WAFIC 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 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 fishery;
- 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;
- Ensure that licence holders 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.

The Department has a general practice of holding regular (often annual) management meetings with fishery licensees to discuss research, management, compliance and other specific issues affecting the fishery (e.g. marine park planning). These AMMs underpin the decision-making process at the fishery-specific level. These meetings are generally coordinated by WAFIC (under the SLA), with the location, timing and priority of the annual management meeting determined by the WAFIC Industry Consultation Unit (ICU) in liaison with relevant Departmental resource managers. The meeting can occur at any time of year with the schedule agreed upon by WAFIC and the Department.

The meetings are attended by Departmental staff, WAFIC and licence holders, but can also be open to other stakeholder groups, e.g. RFW, processors, universities, other Government departments and the conservation sector. The Department is 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.

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 between stakeholders and decision-makers and for discussing new and ongoing management issues. The invaluable information licensees provide to the Department at these meetings is considered when making research, management and compliance decisions.

For recreational fishers, RFW has effective consultation mechanisms including face to face contact, establishment of reference groups and electronic surveys. The consultation process with stakeholders on a recent Statewide review of all recreational fishing rules (e.g. bag and size limits) was comprehensive and transparent.

Other interested stakeholders are recognised on the basis that the fishery:

- Has the potential to interact with socially high-profile species, such as turtles (through boat strikes);
- Has the potential to interact with other marine users including dive and general tourism activities, and marine park planning activities; and
- Provides a product to retailers both locally and overseas.

Based on these characteristics, other stakeholders include:

- Conservation sector representatives (e.g. World Wildlife Fund and Conservation Council of WA)
- Organisations / institutions undertaking research (e.g. WA Department of Parks and Wildlife, Universities, WA Museum);
- Investors, banking representatives, boat brokers, etc.; and
- Retailers.

Other stakeholders have the opportunity to play a role in the management process of fisheries through direct contact with the Department, contact with the relevant sector Association (e.g. the PPA for pearling related issues) or by reporting any illegal fishing to FISHWATCH.

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

- direct consultation in writing;
- press releases;
- newspaper, radio and television interviews;

- dissemination of information via brochures in fishing/tackle stores and 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.

15.2.3 Participation

Both the Department and WAFIC as the peak industry body representing commercial fishing, pearling and aquaculture, are encouraging of stakeholder participation at a management system level through its stakeholder forums, ERA workshops and other meetings. For example, a stakeholder briefing on the WA Government's \$14.5 million initiative to provide every WA commercial fishery the opportunity to be independently certified by the MSC's international gold standard for sustainable fisheries was conducted in March 2014 (see invitation in Appendix J). Invitations to the event were sent to a range of stakeholders including research organisations (Universities, AIMS, CSIRO), Government Departments (DPaW, Tourism, WA Museum, Agriculture, Development Commissions, Local Government), Retailers (Supermarkets, Seafood suppliers), NGOs (Conservation Council, Australian Marine Conservation Society, Wilderness Society, WWF), Education organisations (TAFE, Science Teachers Association, Perth Zoo, Scitech, AQWA) and other representative bodies (RFW, PPA, WAFIC). The event was well attended and well received. A similar event to provide an update on the MSC initiative is being held in October to coincide with the Seafood Directions 2015 conference.

Another recent example of providing an opportunity for broad participation and facilitating their effective engagement was the Environmental Risk Assessment for the Pearling Industry held in Broome in August 2015. People invited to the ERA included representatives from State and interstate Government Departments, the pearling industry, Northern Territory Seafood Council, local environmental groups and WWF. Invitation lists for previous ERAs are included as appendices in the Department's ESD report series that can be found on the website (for example Pearl Oyster Fishery ESD report series No. 5¹).

The PPA has been instrumental in engaging with a wide range of stakeholders, particularly in the development of the Environmental Management System template (see the FRDC funded Seafood EMS Case Studies). The initial pearling environmental assessment in 2001 and a formal risk assessment review, undertaken in 2004, were carried out as workshops with a wide range of participants invited and attending. Participants in these workshops included representatives from Government and non-government agencies, such as the WA Conservation Council, Indigenous Affairs and RFW. Experts in the field of environmental impact were invited to present their findings and discuss application of systems in the pearling industry. These workshops were opportunities for the pearling industry to educate people on management and ensured that any issues that were on the minds of external stakeholders could be discussed in an open forum with gaps in information identified and research determined to help fill the gaps.

¹ http://www.fish.wa.gov.au/Documents/esd_reports/esd005.pdf

The consultation processes undertaken by the Department ensure that stakeholders and the broader community have an increased awareness of and access to relevant information regarding fisheries management. The Department encourages input from stakeholders and the broader community in the management process and facilitates their involvement by making all relevant information available.

Before making a decision around aquatic resource policy, the Minister must demonstrate that he has asked for, and taken into account, interested and affected parties' submissions on policy proposals. The publication of Fisheries Management Papers (FMPs; discussion papers) and draft Ministerial Policy Guidelines on the website is the most common way the Department undertakes wider consultation by inviting stakeholder engagement on fisheries management proposals. The Department and / or Minister is required to take these comments into account before a decision is made in respect to future management.

The "Public Comment" section on the Department's website is being further developed with a view to making it even more identifiable and encourages participation by all sectors. The public comment period that is part of the MSC process is advertised on our website for all WA fisheries under assessment.

To assist in the sharing of information and transparency of fishing related matters, the Department has two e-newsletters. "Catch!"¹ is the recreational fishing e-newsletter that is sent to over 77,000 subscribers every two months. Among other things, it highlights research results and encourages community participation with programs such as the "Send Us Your Skeleton" campaign. The "Freshwater Guardian"² quarterly e-newsletter delivers information on the work and research being conducted in WA's unique freshwater ecosystems. The last edition included articles on native fish, marron and the highlighted the "Don't Dump that Fish" campaign.

WAFIC and RFW also active encourage interested parties to become involved with their shared aquatic resources. 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 their WAFIC and RFW websites (www.wafic.org.au and www.recfishwest.org.au, respectively).

At a fishery specific level, the Department provides many opportunities for interested people to be involved and learn about the pearling industry. Management staff in the Broome Office are readily available and often respond to pearling related public enquiries. The front counter display in the Broome Office has a section on Pearling (Figure 15.2) and the Department has information on Pearling on its website³.

¹ <http://createsend.com/t/y-688A52EA8E6CA32F>

² <http://createsend.com/t/y-8C23D6A42FAD0F84>

³ See <http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Pearling/Pages/default.aspx> and <http://www.fish.wa.gov.au/Species/Pearl-Oyster/Pages/default.aspx>

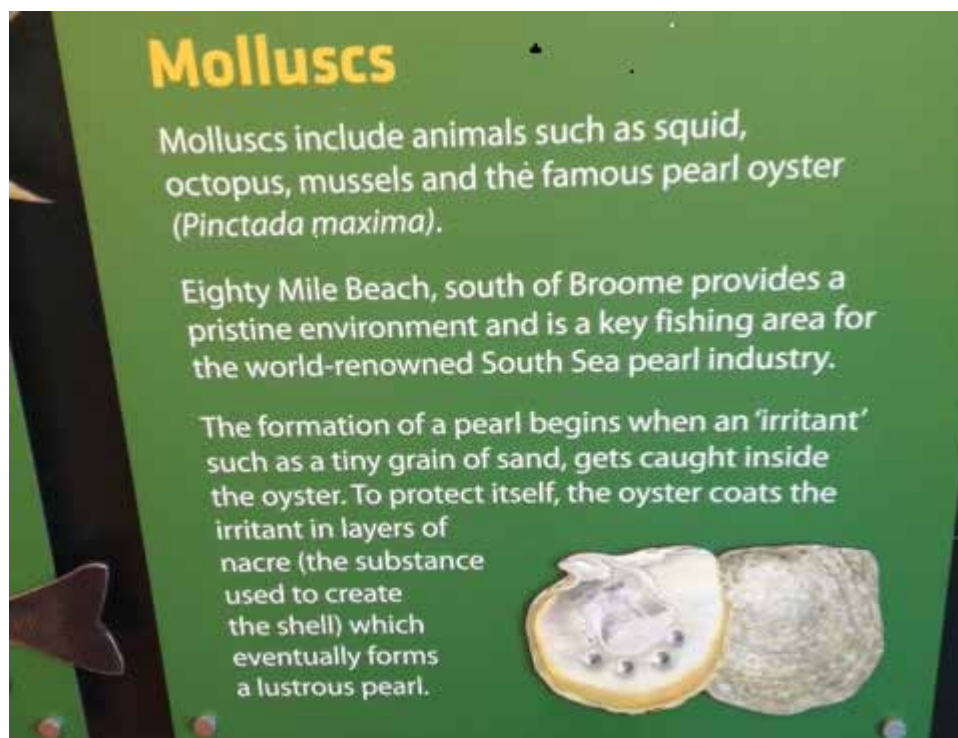


Figure 15.2 Pearl Oyster display in the foyer of the Department of Fisheries Broome Office.

While on patrol, Broome based Fisheries and Marine Officers/Pearling Inspectors regularly get questions from members of the public about the pearling industry, particularly when they see pearling vessels in the area. This educative interaction is a vital component of their job.

The Northern Regional Office in Broome hold annual industry meetings for other northern commercial fisheries in February/March each year and pearling is often discussed with other industry members. Broome staff also regularly meets with members of the Recreational and Charter sectors and pearling is discussed.

Another example of providing opportunities for interested people to learn and become involved with the pearling industry was a major display that was on show at the Perth Royal Show in 2014. The display included aquaria with live pearl oysters and other general information on the pearling industry which attracted hundreds of enquiries and questions. Broome based staff also often discuss pearling at Regional shows, expos and events.

The Festival of the Pearl (also known as Shinju Matsuri) held in Broome over a week each year provides another opportunity for people to learn about the pearling industry and engage with both fishers and management representatives. Various types of media leading up to the Festival encourage community participation on many levels¹. An official announcement by the Minister that the pearling industry was entering into MSC full assessment was made at the beginning of the festival. A media release² and a newsletter article¹ followed this announcement.

¹<https://au.news.yahoo.com/thewest/wa/a/28516986/community-encouraged-to-be-a-part-of-festival/> and <http://www.shinjumatsuri.com.au/about>

²<https://www.mediastatements.wa.gov.au/Pages/Barnett/2015/08/WA-pearls-seek-world-first-sustainability-tick.aspx>

Pearl oyster farm tours are offered by two companies which educates people about the unique pearling industry.

15.3 Long-term objectives

Fisheries management legislation and policy in WA has clear long-term objectives to guide decision-making that are consistent with MSC Principles and Criteria and incorporate the precautionary approach. These objectives are explicit in fisheries legislation and are required by management policy. The Department's *Strategic Plan 2016-2020*², sets out clear and explicit long term biological, ecological, social and economic in three main areas: community and stakeholder benefits, sustainability, and management excellence.

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

- Manages all factors associated with fishing (incorporating 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.
- 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 set out 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;*

¹ <http://www.wamsc.com.au/news/mediaitem.phtml?MediaID=37>

² http://www.fish.wa.gov.au/Documents/corporate_publications/strategic_plan_2016-2020.pdf

- *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;*
- *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.”*

Additionally, 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 measures to ensure the sustainability of fish stocks or the aquatic environment.”

The 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.”

The management and sustainability settings contained within the PA will be incorporated into the new ARMA. The key object of the current PA is *“to regulate pearling and pearl oyster hatchery activities, to provide for the conservation and management of pearl oyster fisheries”*.

In order to effectively deal with community expectations for aquatic resource management, these legislative objectives will be translated into clearly-defined operational arrangements and procedures for each resource / fishery in the form of a fishery- or resource-specific harvest strategies. The harvest strategies will be 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 decision and control rules that describe how fishing exploitation should be adjusted as a function of stock size and other relevant factors (DoF, 2015).

16. Fishery-specific management systems

This section focuses on the management system directly applied to the POF and includes:

- Fishery-specific management objectives;
- The decision-making processes used in the Fishery;
- The compliance and enforcement system and its implementation; and
- An evaluation of the performance of the management system in meeting the Fishery's objectives.

16.1 Fishery specific management objectives

The sustainability of the pearl industry depends on:

- a supply of healthy pearl oysters (see wildstock pearl oyster component);
- the availability of suitable unpolluted grow-out sites (holding sites and farm leases);
- the management of disease risks; and
- management of genetic risks.

The POF 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 PA, PR, MPG 8 and 17, the POF Harvest Strategy (DoF, 2016), codes of conduct and protocols.

The PA provides the overarching legislative framework to implement the management arrangements for the pearling industry, including the collection of wildstock pearl oysters, hatchery production of pearl oysters, cultivation of pearl oysters, and establishment of holding sites and farm leases. The Act specifically states that it serves to:

“regulate pearling and pearl oyster hatchery activities to provide for the conservation and management of pearl oyster fisheries”

MPG 17 outlines a number of guidelines on significant matters that may affect farm leases, licences and permits. The following objectives are explicitly stated in MPG 17:

- control on the collection of wildstock pearl oysters;
- the orderly development of pearl oyster farms;
- the vertical integration of the industry;
- an approach to the growth in production of pearl oysters determined by industry, and based on sensitivity to markets; and,
- market stability; and the retention of the pearling industry in Australian hands.

MPG No 8 outlines the process required for farm lease applications and the requirements for site environmental impact assessment. Specifically the policy states that its objective is “intended to assist in the consideration of applications under Sections 92 and 97 of the *Fish Resources Management Act 1994* and Section 23 of the *Pearling Act 1990* for leases”.

The PR regulates the movement of pearl oyster (Regulation 42) and specifies the requirements of these movements (forms and approvals). The control of disease is managed

through sections of the FRMR and PR, as well as the *Pearl Oyster Translocation Protocol* (Appendix A) that summarises health testing requirements of pearl oysters, prior to movement from hatcheries and between farms. The protocol specifically states that it aims to “minimise the risks of disease introduction into the Western Australian pearl oyster stocks by the movement of hatchery produced spat or farmed oysters and to minimise the effects of a disease following the detection of such an event.”

The Pearl Diving Industry Code of Practice objective is “To promote and encourage industry stakeholders to secure the safety and health of persons who work within the pearling industry” (PPA 2012). Other management instruments and codes of conduct which contribute to the overall management of the POF for long term sustainability include the:

- Environmental Code of Conduct (PPA 2008a); and,
- Whale interaction protocol (PPA 2008b).

16.1.1 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 POF was developed in 2015/16. In line with the Department’s *Harvest Strategy Policy*, POF Harvest Strategy (DoF, 2016) includes:

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

The long and short term (operational) objectives for the POF are provided in the table below.

Table 16.1 Summary of harvest strategy for the POF with management objectives and operational objectives

Component	Long-term Objective	Operational Objectives (Target Reference Levels)
Target species: <i>Pinctada maxima</i>	To maintain spawning stock biomass of <i>P. maxima</i> at a level where the main factor affecting recruitment is the environment	SCPUE of shells 120 to 175 mm is 25 shells per hour; and SCPUE of shells > 175 mm is 15 shells per hour.
Bycatch (non-ETP species)	To ensure fishing impacts do not result in serious or irreversible harm to bycatch species populations.	Fishing impacts are considered to generate an acceptable level of risk to all bycatch species’ populations, i.e. moderate risk or lower.

ETP species	To ensure fishery impacts do not result in serious or irreversible harm to endangered, threatened and protected (ETP) species populations	Fishing impacts are considered to generate an acceptable level of risk to all ETP species' populations, i.e. moderate risk or lower.
Habitats	To ensure the effects of fishing do not result in serious or irreversible harm to habitat structure and function	Fishing impacts are considered to generate an acceptable level of risk to all benthic habitats, i.e. moderate risk or lower.
Ecosystem Processes	To ensure the effects of fishing do not result in serious or irreversible harm to ecological processes	Fishing impacts are considered to generate an acceptable level of risk to ecological processes within the ecosystem, i.e. moderate risk or lower; and Fishing impacts on each ecological resource / asset impacts are considered to generate an acceptable level of risk, i.e. moderate risk or lower.

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 principles of ESD, the POF also has the following long-term social and economic objectives respectively:

- To provide flexible opportunities to ensure fishers can maintain or enhance their livelihood, within the constraints of ecological sustainability; and
- To optimise economic returns to the State through the production of pearls.

Performance against the social objective is measured by determining whether livelihood opportunities are provided to fishers and whether fishers are able to access these opportunities (e.g. maintaining access to a resource, use of transferrable use rights), identifying any constraints on livelihood opportunities imposed by the management system (e.g. high entry costs) and evaluating fisher satisfaction with the management system.

Performance against the economic objective is assessed by monitoring changes in the annual value (GVP) of the industry.

16.2 Decision-making processes

There are established decision-making processes in the management of the pearling industry that result in measures and strategies to achieve the objectives listed above.

There are two main processes for making decisions about the implementation of management measures and strategies in the POF:

- Annual decision-making processes that may result in measures to meet the short-term fishery objectives (driven by the annual quota limit control rules contained in the POF Harvest Strategy); 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).

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.

Once an issue has been identified, mitigation measures are developed and implemented in consultation with the pearling industry. Alternatively, if appropriate, additional research may be undertaken, with research results used to inform management action.

16.2.1 Annual processes

An overview of the annual decision-making processes to achieve short-term operational objectives under the current management framework is described below.

16.2.1.1 Harvest strategy

The POF Harvest Strategy guides management responses in the event that a short-term objective is not met. The harvest strategy control rules and management actions are commensurate with the breach of Reference Levels. The harvest strategy ensures that if catch rates fall below the Target, Threshold or Limit Reference Levels, the sustainable harvest level (SHL) and ultimately the TAC can be reduced between 30 to 100% depending on the severity of the breach. In the event of catch rates falling below a reference level, research and management staff will undertake a review of the reasons for the decreased abundance. This review includes an investigation of any changes that may have taken place in the POF (e.g. fishing grounds, 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 is often 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 the pearling industry by the Department at the SAWG and 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, changes to the management arrangements are discussed with the licensees, with appropriate changes implemented for the following fishing season.

16.2.1.2 Pearl Oyster Stock Assessment Working Group (SAWG)

The POF has a SAWG which meets annually to review scientific data from monitoring programs and to propose management measures such as the allowable harvest range for the following

season and any other potential changes. Meetings are held prior to the AMM to ensure all participants understand the research outcomes and how they will influence management recommendations for the following season. Participants include Department scientists and managers, the PPA and pearling industry representatives. Discussion is centred around:

- Fishery data for the previous years- the number of pearl oysters collected, catch rates, the number of drift dives, fishing locations and months fished;
- Outcomes from stock surveys - size frequency data, populations surveys, spat collection analyses, breeding stock surveys;
- Stock predictions - based on the stock prediction model;
- Allowable harvest range;
- Size limits (including trials); and
- Fishery performance in relation to the harvest strategy.

16.2.1.3 Annual management meetings

The Departmental POF AMM is typically held towards the end of October of each year. Participants include Department staff, the PPA, WAFIC, pearling industry members and other relevant stakeholders (by invitation). The primary objectives of the AMM are to discuss and agree on the management arrangements for the POF for the following season including:

- SAWG recommendations (sustainable harvest level [SHL]) and the potential TAC for the following year;
- Size limits(including trials);
- Evaluation of the fisheries performance; and
- Changes to management arrangements.

One of the major outcomes of the AMM is that after discussing the potential TAC, the PPA makes a formal submission (via letter generally) to the Chief Executive Officer (CEO; also referred to as the DG) of the Department. The DG will consider all advice on the TAC and make a determination (see Section 16.2.1.5). Section 26 of the PA provides the CEO with the power to set the quota of pearl oysters and the relevant area of waters from which pearl oysters maybe taken, via licence condition.

16.2.1.4 Pearl Producers Association (PPA)

The PPA is the main forum for communication between the pearling industry and the Department. Any proposed changes to management and/or fee structures are sent to the PPA to consult with industry. For example, the PPA is responsible for writing to the Department formally communicating industries position on the proposed TAC and the annual access fees.

16.2.1.5 Annual TAC setting process

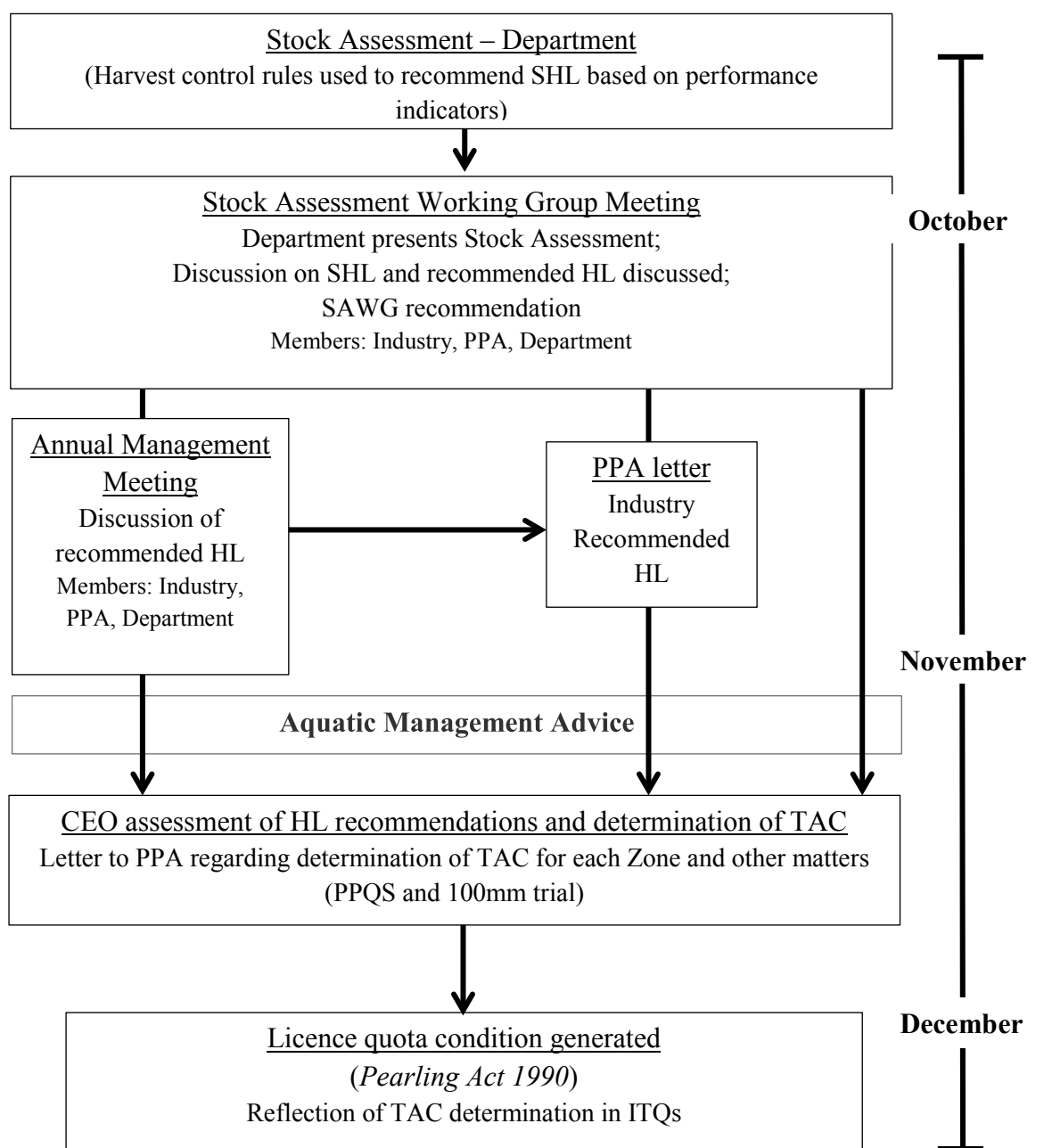


Figure 16.1 Annual TAC setting process for the POF

16.2.2 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.

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 changes in management, 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. an ecological 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 for management.

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 CEO or the Minister) by the relevant Departmental staff (Aquatic Management).

For example, the *P. maxima* resource passed through a phase of high abundance between 2008-2012 due to exceptional recruitment in 2005 and high settlement in 2006 and 2007. It is estimated that only around 50% of these large year cohorts were harvested by the POF when between 120 – 175 mm SL (generally referred to as ‘culture pearl oysters’). The remaining pearl oysters had grown into the breeding stock (> 175 mm). As a result of this high abundance, an annual take of approximately 150,000 pearl oysters of a size greater than 175 mm was considered sustainable by the Department for the 2012 - 2015 seasons. This was reflected in the TAC setting process of the relevant years.

Another example of this is that the legal minimum size of 120 mm has been reduced to 100 mm until December 2016 to trial the suitability of smaller size pearl oysters for pearl production, with no change in the TAC, provided that pearl oysters between 100-119 mm make up less than 15% of the TAC.

16.2.3 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 TAC is the primary mechanism for management of pearl oyster wildstock. It is established annually, based on a function of standardised catch rates and predictive recruitment models from data collected in the previous years. The TAC is discussed with the pearl industry and PPA and determined by the CEO of the Department in early December of each year. This allows sufficient time to produce licence renewals and allow for the scientific data to be collated and analysed.

16.2.4 Use of precautionary approach

The precautionary approach underlies decision making processes for all fisheries in the State (see Section 4 of the FRMA) and is an important consideration in the Department's EBFM framework and risk assessment process. EBFM is 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. The ecological risks associated with each of WA's fisheries are annually assessed and reported within the Status Reports on the fisheries and Aquatic Resources of Western Australia (Fletcher and Santaro 2014). In addition to the annual internal risk assessments undertaken by the Department, external risk assessments involving stakeholders such as industry representatives, PPA, NGO's, other government departments, local councils and indigenous groups are undertaken regularly to ensure that there are no unacceptable threats to the environment from the collection of wildstock pearl oysters, hatchery-production and cultivation of pearls. Risk assessments for the pearling industry were conducted in 1998, 2002, 2004, 2008 and 2015.

The control rules in the POF Harvest Strategy incorporate a precautionary approach to the decision-making process by requiring a review of the fishing activities and management arrangements when a threshold reference level is met (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 (annually) and review allows for management action to alleviate adverse impacts before a limit level is reached and long-term sustainability may be compromised.

Another example of the precautionary approach is in the *Pearl Oyster Translocation Protocol*, in relation to the transport of pearl oysters. Transport vessels are to maintain a standoff distance of 5 nm from 80 Mile Beach fishing grounds and from active farm leases operated by other licensees unless agreed by the licensee that the distance can be less. For transportation of unhealthy pearl oysters from regions or farms where high mortality levels have been incurred transport vessels are to maintain a standoff distance of 10 nm from 80 Mile Beach and Lacepede fishing grounds.

16.2.5 Accountability and transparency

The Department regularly reports to key stakeholders on annual fishery performance, including information on fishery outcomes, management, relevant findings and recommendations from research, monitoring, evaluation and review activities. This information is primarily provided to licence holders at the AMM and SAWG. Additionally, comprehensive information on each of the State-managed fishery's performance, management system, research, monitoring, and other activities are compiled regularly and published in a number of publically-available documents that can be found on the Department's website, including:

- The *Annual Status Reports of the Fisheries and Aquatic Resources of Western Australia: the state of the fisheries* (e.g. Fletcher and Santoro 2014);
- The Department's *Annual Report* to Parliament;
- The *Research, Monitoring, Assessment and Development Plan 2015 – 2020* (RMAD Plan; DoF 2015); and
- Fisheries Management Papers (FMP), Fisheries Research Reports (FRR), Fisheries Occasional Papers (FOP) and peer-reviewed scientific journal articles. For example, recent publications relevant to the POF include:
 - The *Pearl Oyster Resource Harvest Strategy 2015 – 2020*.
 - ESD Report Series No. 5. Pearl Oyster Fishery (Fletcher et al. 2006).
 - Fisheries Research Report No. 138. Historical diving profiles for pearl oyster divers in Western Australia (Lulofs and Sumner 2002).
 - Fisheries Research Report No 232. Aquatic Animal Health Subprogram: Investigation of Chlamydiales-like organisms in pearl oysters, *Pinctada maxima* (Crockford and Jones 2012).
 - Fisheries Occasional Publication No 27. Review of Pearl Oyster Hatchery Policy. Phase II - Policy Direction (Pearling Industry Advisory Committee 2005).
 - Fisheries Research Report No 196. Management of bioeroding sponges in wild stocks of *Pinctada maxima* in Western Australia (Daume et al. 2009).
 - FRDC Research Project 2005/44. Development of the scientific requirements of an Environmental Management System (EMS) for the pearling (*Pinctada maxima*) industry (McCallum and Prince 2005).

The implementation of any new statutory arrangements must be formally communicated to licence holders in writing.

Fishery-specific legislation, including the FRMA, FRMR, PA, PR and Government Gazettes are publically available on the State Law Publishers Website¹.

The management system is able to respond to findings and recommendations emerging from research, monitoring, evaluation and scientific publications, for example:

- The *Harvest Strategy* guides the annual setting of the TAC based on research and monitoring of catch and recruitment rates;
- The prioritisation of research and monitoring driven by periodic risk assessments (e.g. FRDC Projects, 2005/44, 2005/074, 2008/031) and the subsequent development of management and policy where applicable (e.g. development of the *Pearl Oyster Translocation Protocol* 2009, Appendix A).

¹ State Law Publisher website <https://www.slp.wa.gov.au/index.html>

16.2.6 Approach to disputes

The POF decision-making process proactively avoids legal disputes through the inclusion of and, where appropriate, consultation with stakeholders. This allows for all impacts of proposed management changes to be considered and for the resolution of conflicts. Additionally, the collaboration and regular communication between the Department and the PPA has resulted in a mutual and in-depth understanding of pearling industry operations and the fishery management system. The AMM is the key forum for discussion of management matters in the POF.

Should a dispute arise, there are well-established mechanisms for administrative and legal appeals of decisions, as prescribed under Sections 33 and 34 of the PA.

16.3 Compliance and enforcement

In order to optimally utilise compliance resources, enforcement effort is designed to maximise the potential for licence holders and fishers to voluntarily comply with legislation, while at the same time provide a reasonable 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 education campaigns.

The Department's Regional Services Division (RSD) delivers the Department's compliance and education services, with the support of the Communications and Education Branch. There are approximately 170 RSD employees 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.

The POF is part of the NBR for compliance purposes, and compliance and community education services are delivered by Fisheries and Marine Officers (FMOs¹), Community Education Officers and associated management and administrative support staff based at the Kununurra, Broome and Karratha offices, state-wide mobile patrol units and officers aboard the large, ocean-going patrol vessel, the PV Walcott.

¹ FMOs defined under section 4(1) the FRMR, are Inspectors under section 35(2) of the PA.

During 2012/13, the Northern Region FMOs delivered a total of 7,751 hours of compliance and community education services in the field (Fletcher and Santoro, 2014). A continuing emphasis was placed on employing risk- and intelligence-based approaches to compliance planning and prioritisation. The POF is the second largest commercial fishery in the state, therefore a significant compliance focus in the Northern Region is on the POF.

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 FMOs from the Broome Office include licensing checks and issuing of tags and transport approvals. Sea-based patrols utilise vessels ranging in size from five to 23 metres. FMOs provide support to seagoing personnel and provide a wide variety of educational and extension services through formal and informal media to commercial fishers, other resource management agencies and community members (Fletcher and Santoro, 2014).

16.3.1 Monitoring, Control and Surveillance (MCS) Systems

Monitoring, control and surveillance (MCS) mechanisms ensure a fishery's management measures are enforced and complied with. The MCS system for the POF is administered by the Department's RSD through the Pearling Operational Compliance Plan.

16.3.1.1 Implementation

16.3.1.2 Compliance risk assessments

The Department conducts compliance risk assessments every 1 – 2 years in major fisheries (e.g. the POF) or those perceived to be at high risk and every 3 – 5 years in minor fisheries. The risk assessment process feeds into an Operational Compliance Plan¹ (OCP), which provides the formal framework for the delivery of specific compliance services that remove or mitigate those 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 through Fish Plan. The risk assessment process can be triggered by the introduction of new legislation 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;
- Market changes;

¹ By their nature, finished OCPs contain sensitive information and are only made available to authorised compliance personnel.

- Intelligence; and/or
- Upward trend in non-compliance.

There are broadly three levels of compliance risk assessment and associated planning and monitoring undertaken by the RSD. The POF undergoes an annual Level 1 compliance risk assessment, planning and monitoring, with a review and update of compliance assessment and associated compliance strategies, manuals and procedures. The POF is scheduled to undergo a more intensive Level 3 compliance risk assessment with the introduction of ARMA in 2016. Risk assessments are usually undertaken by the relevant Compliance Manager, in consultation with the Regional Manager, Regional FMOs and Fisheries Management Officers, and Supervising FMOs, with a focus on preparing annual work programs and taking into account changes affecting the fishery.

16.3.1.2.1 Operational Compliance Plan

The Pearling OCP provides a formal process for staff to carry out defined compliance activities in order to monitor, inspect and regulate the compliance risks in the POF, and in turn confirm they are at an acceptable and manageable level. The Pearling OCP is reviewed following each compliance risk assessment. Regular reviews of the Pearling OCP also allow accountable decisions in relation to deploying compliance resources and ensuring that resources are available to mitigate risks to an acceptable level.

Following a formal review of the OCP and associated compliance strategies, compliance activities are prioritized in accordance with risk, budget and resourcing considerations.

Annual planning meetings are held for the Pearling OCP, with regular specific planning of day-to-day targeted and non-targeted patrols linked to the Pearling OCP based on resources and competing priorities.

16.3.1.2.2 Resourcing compliance operations

RSD staff 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 hours 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.

16.3.1.2.2.1 Key compliance personnel in the Northern Region

The Regional Office of the Department relevant to the POF is located in Broome, and staff located at this office provide the primary on-ground compliance and education delivery for the fishery. Key compliance and enforcement personnel located in the region and their responsibilities include:

1. Compliance Manager

- Overall responsibility for OCPs and compliance strategies, including their development, review and ensuring outcomes are delivered;
- Responsible for providing sufficient and appropriate resources to achieve compliance outcomes;
- Ensuring Pearling Inspectors (PI) safety is considered at all times and the Region's occupational health and safety requirements are met;
- Monitoring the progress of the OCPs and strategies during their execution;
- Consulting with all key stakeholders when reviewing the OCPs and strategies; and
- Compiling reporting outcomes.

2. Supervising PI (FMO)

- Field responsibility for OCPs and strategies, including reporting any deficiencies and reporting the outcomes as they are delivered or achieved;
- Supervision of staff performance;
- Ensuring officer safety is considered at all times and the district's occupational health and safety requirements are met;
- Provide briefings and de-briefings as required;
- Ensuring all equipment required to execute the OCPs and strategies is serviced, operational and available;
- Liaising with staff from other agencies operating in a joint servicing arrangement; and
- Reporting outcomes.

3. PI (FMOs)

- Day-to-day responsibility for the execution of the OCPs and strategies in their interaction with users of the Fishery;
- Ensuring safety is considered at all times and individual occupational health and safety requirements are met;
- Reporting any deficiencies and outcomes in a timely and accurate manner;

- Complying with the, *Prosecution Guidelines*¹, the Department's *Code of Conduct* and promoting the vision and mission statement of the Department and its joint-servicing partners; and
- Carrying out prosecution actions within agreed timelines.

PIs are formally appointed pursuant to the PA. The PA clearly sets out their powers to enforce pearling legislation. A PI may enter and search vessels, aircraft or space for the purposes of the PA. Inspectors are highly trained; they must have a thorough knowledge of the legislation they are responsible for enforcing and follow a strict protocol for undertaking their duties in accordance with the PA and in recording 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. Patrol Boat Business Unit
 - Provides large oceangoing patrol vessels for State-wide offshore compliance operations and education activities.
2. Vessel Monitoring System² Unit
 - Operates the Department's vessel monitoring system (VMS) to help manage the State's commercial fisheries.
3. 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.
4. Fisheries Intelligence Unit
 - Responsible for providing intelligence reports to support strategic, operational and tactical needs of compliance programs; and
 - Collects and analyses compliance data.
5. Compliance Statistics Unit
 - Develop monitoring and sampling programmes to support compliance delivery;
 - Collects and analyses compliance data to identify trends; and
 - Provides compliance statistics to help target enforcement activities.

¹ The *Prosecution Guidelines* is a confidential guide used by Inspectors that provides a tiered framework for dealing with fishery offences, thus it is not a publically-available document.

² Note VMS is not used for POMF vessels

6. Prosecutions Unit

- Manage the electronic system used to issue warnings or commence prosecution processes when offences are detected; and
- Custodians of information relating to detected offences which can be used for official reporting purposes.

7. 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.

16.3.1.3 Formal monitoring, control and surveillance systems

There are four focal areas for monitoring, control and surveillance in the POF:

1. Enforcement of wildstock pearl oyster quota;
2. Translocation of pearl oysters and disease management;
3. Pearl oyster farm leases; and
4. Hatchery operations.

16.3.1.3.1 Wildstock pearl oyster quota management

The long term sustainability of wildstock pearl oysters are primarily managed through the annual setting of the TAC and the associated annual allocation of quota. The quota is primarily enforced through the use of serially coded lockable tags which are issued by the Department on an annual basis based on quota (PR, Part 4). Tags are issued in accordance with the types of containers (otherwise known as panels) used to hold the pearl oysters, with the most common types being either six or eight pockets for cultured pearl oysters and a PI approved container for pearl oysters taken for other purposes (MOP and pearl oyster meat). One tag is issued for each container with the number of tags corresponding to the number of pearl oysters collected.

Quota compliance is primarily conducted by inspecting pearl oysters on-board vessels and associated tags and paperwork. Any panels without a tag are considered to be taken outside of quota and could result in prosecution, with penalties commensurate with the number of pearl oysters over quota (Section 9 of the PA). Quota inspections typically occur whilst fishing for pearl oyster wildstock is occurring or when pearl oysters are being transported from holding sites to farm leases. There are three primary logsheets used in the tracking and enforcement of quota:

- *Notice of Pearling or Hatchery Activity* – Form P2. To be completed prior to any pearling activity has occurred, including the collecting, transporting or operating on pearl oysters. The proposed activity cannot legally proceed without written approval from the Department (Appendix K).
- *Pearl Oyster Fishing Daily Logsheet* – Form P3. Daily records of pearl oysters collected by each diver and for the boat. Also recorded are the number of tags used, the tag serial numbers and dump locations. This paper work is legally required to be completed by 2200 of each day and is the primary mechanism for quota monitoring (Appendix E).
- *Transport log sheet*– Form P6. Required for transport of pearl (Appendix L).

Wildstock pearl oyster quota enforcement generally occurs prior to or when shell are transported to the farm leases. Section 30 of the PR requires that all shell are transported to a farm lease by the 31st of December each year.

16.3.1.3.2 Translocation of pearl oysters and disease management

Legislation governing pearling translocation includes the following measures aimed at reducing risk for the introduction of pests and diseases.

- Part 13A (Control of disease in pearl oysters) of the FRMR ;
- Part 7 of the PR;
- MPG No. 17;
- The *Pearl Oyster Translocation Protocol* (Appendix A); and
- MOU between the WA and NT governments.

16.3.1.3.3 Pearl oyster farm leases

There are several instruments that contain measures designed to minimise the impact of pearl farms on the surrounding environment and the potential for the spread of disease, these are:

- Section 23 of the PA
- Part 5A of the PR;
- MPG 8;
- MPG 17; and
- Lease conditions.

16.3.1.3.3.1 Pearling Act (Section 22 and 23)

The PA provides a measure of control and monitoring for farm leases through the following requirements:

- Granting, renewal or transfers of farm leases requires approval by the CEO;
- General restriction of farm leases to 4 square nautical miles;

- New farm leases cannot be granted in marine nature reserves, areas of marine parks and marine managed areas from which pearling is excluded, unless the Minister who administers the *Conservation and Land Management Act 1984* approves.

16.3.1.3.3.2 Ministerial Policy Guideline No 8 and 17

MPG 8 and 17 assists in the management of the pearling industry on a range of issues. The MPGs seek to guide the pearling industry in relation to applications for farm leases. Applications for new farm leases or extension of farm lease areas require approval by the CEO and are to be progressed in accordance with the MPGs and need to demonstrate the following:

- Minimum required distance between farm leases (or agreement of holders of the surrounding farm leases) ;
- Minimum required distance between holding sites and farm leases (or agreement of holders of the surrounding holding sites and/or farm leases);
- Size of the farm lease is in accordance with applicants requirements.

16.3.1.3.3.3 Farm leases inspections

Each year pearl oyster farm lease inspections are undertaken by Departmental staff. The key factors inspected are:

- Orderly development of farm leases;
- Farming operations are away from sensitive habitats such as coral reefs and seagrass;
- Operations are restricted to within the farm lease boundaries;
- Presence of rubbish both inside and outside of farm lease areas; and
- Farm leases are adequately marked and lit to indicate location to other vessels in the area.

16.3.1.3.4 Marine Park compliance

There are two established marine parks within the boundaries of the POF – Eighty Mile Beach and Camden Sound. There are a further three proposed marine parks in the Kimberley. Pearling operations are permitted within the general use zones of the marine parks but restricted from Sanctuary, Recreation and certain Special Purpose zones. The zones in which pearling activities are restricted are generally not suitable for pearling operations. Regular marine patrols are undertaken within the marine park to ensure that pearling activity is not occurring in restricted areas. There are currently several dedicated vessels and staff for marine patrols of the marine parks both within the Department and DPaW.

16.3.1.3.5 Daily patrol contact form

Surveillance and compliance activities undertaken during air, sea and land based patrols are recorded and reported by PIs using a daily patrol contact (DPC) form (Appendix N). The purpose of these forms is to record and classify contacts and time spent in the field for each PI. These forms provide managers with information about:

- The number of field contacts made, which provides a context for the number of offences detected and reported. This includes random contacts and offences from random inspections;
- The number of targeted¹ 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 educative effort of PI/FMOs in a fishery; and
- Other routine information that can be used to help managers’ report on where and which fisheries FMOs have undertaken patrols. This information is also used in patrol planning and risk assessments and ensures accountability of the compliance program.

A ‘contact’ occurs when a PI/FMOs has a chance of detecting illegal activity being undertaken by a fisher and includes personal contact (face-to-face), covert activities (e.g. deliberate, intensive surveillance) and unattended gear checks (e.g. traps; contact statistics available in Table 16.2).

Table 16.2. Contact details for the POF for 2010 – 2014

Vessel	Year				
	2010	2011	2012	2013	2014
Vessels	4	8	10	12	12
Leases	12	14	0	11	3
Total	16	22	10	23	15

The DPC form also includes a section to record details of individual commercial vessel inspections / checks. These inspections may involve:

- Inspection of quota;
- Inspection of pearl oysters
- Inspection of pearling equipment
- Inspection of pearling leases
- Logbook inspections
- Inspection of licences; and
- Inspection of pearling vessels including freezers and fish on board the boat.

The Department has also implemented an initiative called Fishwatch², 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.

¹ 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.

² <http://www.fish.wa.gov.au/About-Us/Contact-Us/Pages/Fish-watch.aspx>

16.3.2 Applying sanctions

There is an explicit and statutory sanction framework that is applied should a person and/or company contravene legislation relevant to the POF. Sanctions to deal with non-compliance are listed in the PA and PR and can be severe. These sanctions consist of:

- Significant monetary penalties;
- Licence and permit cancellations or suspensions;
- Pearl oyster farm lease cancellations;
- Confiscation of gear and catch.

Breaches may occur for a variety of reasons, and PI/FMOs undertake every opportunity to provide education, awareness and advice to fishers. There are two levels of enforcement applied by PIs when an offence is detected in the POF:

- Letter of warning: A letter of warning is a formal record of a commercial offence where a prosecution may be unduly harsh under the circumstances. There may not be a public interest in prosecution, but this still formally records the detected offence. A letter of warning formally advises the offender of their actions and seeks future ‘voluntary’ compliance.; and
- Prosecutions: These are offences of serious nature (prescribed in the PA) that proceed to formal, legal prosecution which are brought before the court. Such matters can incur heavy fines.

In the case of prosecutions, the Department has a Prosecution Advisory Panel (PAP) which reviews recommendations made by the Pearling Inspector in regard to offences against the PA 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 recorded on the Department’s website¹.

Penalties for illegal activity in WA fisheries are commensurate with the value type and magnitude of illegal activity. Under the PA for quota offences the penalty increases in accordance with the number of oysters over quota, with the penalty ranging between \$10,000 and \$100,000.

All fisheries offences in WA are recorded in a dedicated Departmental offences system, which also manages the workflow associated with warnings and prosecutions. In order to link

¹ Example of media release: <http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/Court-fines-hit-hard-for-out-of-season-lobster-fishing.aspx>

this information with patrol data, PIs include information about the fishery, DPC area, type of patrol and whether the offence resulted from a targeted inspection in all offence paperwork.

16.3.2.1 Sanctions in the POF

There have been relatively few offences detected in the POF in the last six years with none detected in 2009/10 and 2010/11 (Table 16.3). The offences listed in Table 16.3 are related to those associated with the wildstock fishery. Most of the offences have only involved a letter of warning and there have been no prosecutions in the past six years. There has been only once offence relating to a lease areas which was in 2010/11 where a farm was insufficiently marked and lit.

Table 16.3 Number and types of offences in the Wildstock Pearl Oyster Fishery

	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Administration Offences						
- Letter of warning	1			3		2
- No further action				3		
Licencing offences						
- Letter of warning						
- No further action				1	1	
Other offences						
- Letter of warning				2		
- No further action				5		
Returns/Records Offences						
- Letter of warning				2	5	
- No further action				3		

16.3.3 Level of compliance

In evaluating compliance in a specific fishery, the Department uses a weight-of-evidence approach, which considers:

- Ongoing evidence of a sustainable fishery, 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 —
 - Number of offences and successful prosecutions (dependent on whether compliance is undertaken in a random or targeted manner);
- Number of reports of illegal activity logged by Fishwatch and from intelligence gathered by FMOs;
- General level of industry support / buy-in around fishing rules; and

- Level of compliance education and communications during key stakeholder engagement (at least annually).

Using this weight-of-evidence approach, there is a high degree of confidence that the *P. maxima* industry comply with the POF management system in place, including providing information of importance to the effective management of the fishery based on the following:

- There is ongoing evidence that the POF is operating sustainably, as the performance indicators for each component (i.e. target species, retained non-target species, bycatch, ETP species, habitat and ecosystem processes) of the POF have generally been maintained above threshold reference levels.
- There have been few offences recorded (based on formal compliance systems) in the POF within the last six years.

16.3.4 Systematic non-compliance

There is no evidence of systematic non-compliance within the POF.

16.4 Monitoring and management performance evaluation

There is a system in place for monitoring and evaluating the performance of the POF management system against its objectives. An annual review of the fishery's performance is undertaken by Departmental research, management and compliance staff, with outcomes used to assess the extent to which the fishery's management system has met both the long- and short-term objectives.

16.4.1 Evaluation coverage

Performance against the short-term (annual) objectives is measured using the performance indicators, reference levels and management control rules that are explicitly identified in the POF Harvest Strategy. Where the 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. In the case that the review indicates that the management system is not achieving the desired objective, appropriate management action will be undertaken to reduce fishing impacts to an acceptable level.

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: state of the fisheries* (SRFAR) (Fletcher & Santoro 2014).

The OCP and compliance statistics are reviewed at the end of the season and prior to the planning stage of the next season to ensure its effectiveness. The plan is modified yearly to take into account changes in technology, fishing practices, community attitudes and environmental factors.

16.4.2 Review of the management system

16.4.2.1 Internal review

16.4.2.1.1 FishPlan

FishPlan is the guiding document that outlines the review schedule for the 5 year planning schedule and the next planning cycle. It includes a timeframe for review of compliance activities and management. Scientific reviews for some resources may also be identified in FishPlan. This process is established by the Department to provide formal independent or Departmental level reviews of specific research projects or monitoring and assessment programs/outputs to ensure continued relevance and/or focus on continuous improvement and best practice. FishPlan undergoes an annual review that involves input from WAFIC and RFW.

16.4.2.1.2 Annual status report

Overall performance is reviewed and reported on annually in the SRFAR. The EBFM risk assessment process is also reviewed annually reported on in SRFAR and informs the decisions and priorities of management. There are numerous internal validation processes that are undertaken to ensure all of the catch and effort data that is compiled for the SRFAR is presented accurately. Routine validation within the database checks for errors and inconsistencies within the data.

16.4.2.1.3 Annual management meetings

The AMM and SAWG are an informal process of review with stakeholders, at which management options are discussed.

16.4.2.1.4 Review of fishery risk levels

Risk assessments are undertaken periodically (every 3 – 5 years) to reassess any current or new issues that may arise in the fishery; 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 FishPlan, the POF Research Plan and compliance requirements. This review also takes into account the level of resourcing across the management, research and compliance divisions for the POF, which can be modified if the level of risk indicates a change is required. The most recent risk assessment was undertaken in August 2015.

16.4.2.1.5 Review of harvest strategy

The POF Harvest Strategy was subject to extensive internal (within the Department's management and research divisions) and external (PPA) review in 2015/16, as part of the preparation for MSC full assessment. While the next formal review of the *Harvest Strategy* is scheduled to occur in 2020, the appropriateness of the current performance indicators, reference levels and control rules may be further refined and updated in the interim (in consultation with the licence holders) as additional information becomes available (e.g. new research results, updated risk assessments, expert advice, etc.).

16.4.2.2 External review

16.4.2.2.1 Export approval under the EBPC

The POF's management system has been the subject of periodic external review as part of the process undertaken to achieve accreditation by the Commonwealth DoE against the *Guidelines for the Sustainable Management of Fisheries – V2* (the *Guidelines*; CoA 2007).

The POF has been assessed under the EPBC for the purposes of the protected species provisions (Part 13 of the EPBC) and the wildlife trade provisions (Part 13A of the EPBC).¹ The most recent assessment (2013) took into account measures that have been developed by the Department in response to conditions and recommendations made in the 2010 assessment of the POF, with four recommendations provided as part of this assessment:

1. Operations of the fishery will be carried out in accordance with the *WA Pearling Act 1990*, *WA Pearling (General) Regulations 1991* and Ministerial Policy Guideline No 17; Pearling Oyster fishery
2. The Department to advise the DoE of any intended material change to the fishery's legislated management regime and management arrangements that could affect the assessment against which EPBC decisions are based;
3. The Department is to produce and present reports to the DoE annually (as per Annex B of the *Guidelines for the Ecologically Sustainable Management of Fisheries 2nd Edition*);
4. As appropriate, the Department to implement recommendations for the Western Australian Pearling Industry, An Independent Review of the Compliance Program, when transitioning the operation and management of the WA Pearl Oyster Fishery to new state legislation incorporating the *Pearling Act 1990*.

In August 2015, the accreditation period for the POF was extended until May 2025.

16.4.2.2.2 Other reviews

The environmental effects of the pearling industry have also been periodically assessed using independent external consultants. The most recent environmental audit and risk assessment was undertaken in 2015, completed by the Department and the PPA and involved external stakeholders. Prior risk assessments were undertaken separately for the collection of pearl oyster wildstock and cultivation of pearl oysters and pearls. Previous independent assessments on the cultivation of pearl oysters and pearls were conducted in 2004 (PPA 2004), 2001 (Jernakoff 2002) and 1998 (Enzer Marine Environmental Consulting 1998). Previous independent assessments of the collection of pearl oyster wildstock were held in 2001, as a part of the ESD assessment.

The PPA reviews the Codes of Conduct regularly, for example, the Pearl Diving Code of Conduct has been reviewed and amended six times since 2000.

¹ <http://www.environment.gov.au/marine/fisheries/wa/pearl>

17. References

17.1 General References (Sections 1– 4)

- Akerman, K. and Stanton, J. (1994). Riji and Jakoli: Kimberley Pearl shell in Aboriginal Australia, Northern Territory Museum of Arts and Sciences, Darwin
- Bearham, D., Spiers, Z., Raidal, S., Jones, J. and Nicholls, P. (2008). Spore ornamentation of *Minchinia occulta* n. sp.(Haplosporidia) in rock oysters *Saccostrea cucullata* (Born, 1778). *Parasitology* 135(11): 1271.
- Benzie, J. and Smith, C. (2006). Microsatellite variation in Australian and Indonesian pearl oyster *Pinctada maxima* populations. *Marine Ecology Progress Series* 314: 197-211.
- Brewer, D., Lyne, V., Skewes, T. and Rothlisberg, P. (2007). Trophic systems of the North West Marine Region. CSIRO, Cleveland: Department of the Environment and Water Resources.
- Bulman, C. (2006) Trophic webs and modelling of Australia's North West Shelf- Technical Report No. 9. North West Shelf Joint Environmental Management Study; CSIRO.
- Campbell, N.A. (1996). Biology, 4th edition. The Benjamin/Cummings Publishing Company, Inc., San Francisco.
- Caputi, N., Feng, M., Pearce, A., Benthuyssen, J., Denham, A., Hetzel, Y., Matear, R., Jackson, G., Molony, B., Joll, L., and Chandrapavan, A. (2015). Management implications of climate change effect on fisheries in Western Australia. Part 1. Environmental change and risk assessment. Department of Fisheries Western Australia, September. CC BY 3.0
- Commonwealth of Australia (2006). A Guide to the Integrated Marine and Coastal Regionalisation of Australia Version 4.0. Department of the Environment and Heritage, Canberra, Australia
- Commonwealth of Australia (CoA) (2007). A Characterisation of the Marine Environment of the North-west Marine Region. A summary of an expert workshop convened in Perth, WA, 5-6 September 2007. Canberra: DEWHA.
- Condie, S.A., Mansbridge, J.V., Hart, A.M. and Andrewartha, J.R. (2006). Transport and recruitment of silver-lip pearl oyster larvae on Australia's North West Shelf. *Journal of Shellfish Research* 25(1): 179-185.
- Daume, S., Fromont, J. and Hart, A.M. (2009). Management of Bioeroding Sponges in Wild Stocks of *Pinctada maxima* in Western Australia: Final FRDC Report on Project No. 2005/074. Fisheries Research Report No. 196, Department of Fisheries, Western Australian. 48 pp.
- Department of Environment, Heritage, Water and the Arts (DEWHA) (2008). Marine Bioregional Planning in the North-West. Canberra, ACT: DEWHA.
- Department of Fisheries WA (DoF) (1998). Fisheries Ministerial Policy Guidelines: assessment applications for authorisations for Aquaculture and Pearling in coastal waters of Western Australia. MPG No. 8, Department of Fisheries WA. http://www.fish.wa.gov.au/Documents/ministerial_policy_guidelines/fmpg008.pdf

- DoF (2001). Fisheries Ministerial Policy Guidelines No. 17: Pearl Oyster Fishery; issued pursuant to Section 24 of the *Pearling Act 1990*.
- DoF (2008). Application to the Department of Environment, Water, Heritage and the Arts on the Western Australian Pearl Oyster Fishery: against the *Guidelines for the Ecologically Sustainable Management of Fisheries*. Department of Fisheries WA, Perth. 12 pp.
- DoF (2011). State of the Fisheries and Aquatic Resources Report 2010/11. Fletcher, W.J. and Santoro, K. (eds.). Department of Fisheries, Western Australia.
- DoF (2013). Application to the Department of Sustainability, Environment, Water, Populations and Communities on the Western Australian Pearl Oyster (*Pinctada maxima*) Fishery: against the *Guidelines for the Ecologically Sustainable Management of Fisheries*. Department of Fisheries WA, Perth. 9 pp.
- Department of Transport (DoT) (2014). Port Authorities in Western Australia.
<http://www.transport.wa.gov.au/imagery/port-authorities.asp>
- Dybdahl, R. and Pass, D.A. (1985). An investigation of mortality of the pearl oyster, *Pinctada maxima*, in Western Australia. Department of Fisheries WA.
- Enzer Marine Environmental Consulting (1998). The environmental impact of pearling (*Pinctada maxima*) in Western Australia. Report to the Pearl Producers Association, Perth WA.
- Fletcher, W., Friedman, K., Weir, V., McCrea, J. and Clark, R. (2006). ESD Report Series No 5: Pearl Oyster Fishery. Perth: Department of Fisheries WA.
- Fletcher, W. and Santoro, K. (2014). Status reports of the fisheries and aquatic resources of Western Australia 2013/14: the state of the fisheries. Perth, WA: Department of Fisheries.
- Hart, A.M. and Friedman, K.J. (2004). Mother-of-pearl shell (*Pinctada maxima*): stock evaluation for management and future harvesting in Western Australia. FRDC Report - Project 1998/153. Department of Fisheries, Western Australia.
- Hart, A.M. and Joll, L.M. (2006). Growth, mortality, recruitment and sex-ratio in wild stocks of silver-lipped pearl oyster *Pinctada maxima* (Jameson) (Mollusca: Pteriidae), in Western Australia. *Journal of Shellfish Research* 25(1): 201-210.
- Hart, A.M., Thomson, A.W. and Murphy, D. (2011). Environmental influences on stock abundance and fishing power in the silver-lipped pearl oyster fishery. *ICES Journal of Marine Science: Journal du Conseil* 68(3): 444-453.
- Hart, A., Murphy, D. and Jones, R. (2014). Pearl Oyster Managed Fishery Status Report. In: W. Fletcher and K. Santoro (eds.) Status report of the fisheries and aquatic resources of Western Australia 2013/14: the state of the fisheries. Department of Fisheries WA, Perth, pp. 213 – 218.
- Humphrey, J.D. (2008). Disease and predation. In: P.C. Southgate and J.S. Lucas (eds.). The pearl oyster, pp. 367-437. Elsevier: Amsterdam, the Netherlands.

- Humphrey, J.D. and Barton, M. (2009). An unsuccessful attempt to experimentally transmit "oyster oedema disease syndrome" to pearl oyster spat. In: Technote. (Northern Territory Government).
- Hynd, J. (1955). A Revision of the Australian Pearl-shells, Genus *Pinctada* (Lamelli-branchia). *Marine and Freshwater Research* 6(1), 98-138.
- Jernakoff, P. (2002). Environmental risk and impact assessment of the pearling industry. Project Report No. 2001/099 to the FRDC by IRC Environmental, Perth, WA.
- Johnson, M. and Joll, L. (1993). Genetic subdivision of the pearl oyster *Pinctata maxima* (Jameson, 1901)(Mollusca: Pteriidae) in northern Australia. *Marine and Freshwater Research* 44(4): 519-526.
- Joll, L.M. (1996). Stock evaluation and recruitment measurements in the WA pearl oyster fishery. FRDC Project 92/147, Department of Fisheries WA. 63 pp.
- Knuckey, I.A. (1995). Settlement of *Pinctada maxima* (Jameson) and other bivalves on artificial collectors in the Timor Sea, Northern Australia. *Journal of Shellfish Research* 14(2): 411-416.
- Mackie, M., Nardi, A., Lewis, P. and Newman, S. (2007). Small Pelagic Fishes of the North-West Marine Region. Perth: Department of the Environment and Water Resources; Department of Fisheries WA.
- Malone, F.J., Hancock, D.A. and Jeffriess, B. (1988). Final report of the Pearling Industry Review Committee. Fisheries Management Paper No. 17, Fisheries Department WA, 216 pp.
- Mills, D. (2000). Combined effects of temperature and algal concentration on survival, growth and feeding physiology of *Pinctada maxima* (Jameson) spat. *Journal of Shellfish Research* 19(1): 159 – 166.
- Mills, D. (2004). Spat Culture of *Pinctada maxima*. PhD thesis, Charles Darwin University, Darwin.
- Minaur, J. (1969). Experiments on the artificial rearing of the larvae of the *Pinctada maxima* (Jameson) (Lamellibranchia). *Australian Journal of Marine and Freshwater Research* 20: 175 – 187.
- Nugranad, J., Traithong, T. and Promjinda, K. (1998). Hatchery seed production of gold-lipped pearl oyster *Pinctada maxima* (Jameson). *Proceedings of the Ninth workshop of the Tropical Marine Mollusc Programme, Indonesia. Part 1* 19: 247 – 248. Special Publication Phuket Marine Biology Centre.
- Pauly, D. (1984). Length-converted catch curves: a powerful tool for tropical fisheries research (II) *Fishbyte* 2(1): 17-19.
- Pass, D.A. and Perkins, F.P. (1985). Protistan parasites or residual bodies in *Pinctada maxima*. *Journal of Invertebrate Pathology* 46: 271 – 281.
- Pass, D.A., Dybdahl, R. and Mannion, M.M. (1987). Investigations into the causes of mortality of the pearl oyster, *Pinctada maxima* Jameson, in Western Australia. *Aquaculture* 65: 149 – 169.

- Pass, D.A., Perkins, F.P. and Dybdahl, R. (1988) Virus-like particles in the digestive gland of the pearl oyster *Pinctada maxima*. *Journal of Invertebrate Pathology* 51; 166 – 167.
- Pearce, A. and Walker, D. (1991). The Leeuwin Current: an influence on the coastal climate and fisheries of Western Australia. *Journal of the Royal Society of Western Australia*.
- Pearl Producers Association (PPA) (2004). Workshop report: 2004 Environmental Risk Assessment of the Pearling Industry. Seafood Services Australia. <http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix2.pdf>
- PPA (2008a). Pearling in Perspective: an overview of the Australian pearling industry and its environmental credentials. <http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix2.pdf>
- PPA (2008b). *Pearling Industry Whale Management Policy and Protocol*. Pearl Producers Association, WA. 10 pp. <http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix4.pdf>
- Rose, R.A. (1990) A manual for the artificial propagation of the silver-lip or gold-lip pearl oyster *Pinctada maxima* (Jameson) from Western Australia. Fisheries Department WA, Marine Research Laboratories, North Beach, WA.
- Rose, R.A. and Baker, S.B. (1994). Larval and Spat Culture of the Western Australian Silver- or Gold Lip Pearl Oyster, *Pinctada maxima* (Jameson) (Mollusca: Pteriidae). *Aquaculture* 126(1): 35 – 50.
- Rose, R.A., Dybdahl, R.E. and Harders, S. (1990). Reproductive cycle of the Western Australian silver-lip pearl oyster, *Pinctada maxima* (Jameson) (Mollusca: Pteriidae). *Journal of Shellfish Research* 9(2): 261 – 272.
- Saucedo, P.E., and Southgate, P.C. (2008). Reproduction, development and growth. In: P.C. Southgate and J.S. Lucas (eds.), *The pearl oyster*, pp. 131-186. Elsevier: Amsterdam, the Netherlands.
- Scoones, R.J.S. (1991). Research on practices in the Western Australian cultured pearl industry. Final report to FRDC project BP12. MG Kailis Group of Companies.
- Southgate, P.C. and Lucas, J.S. (2008). *The Pearl Oyster*. Elsevier Science, Amsterdam; London.
- Talavera, F. (1930). Pearl Fisheries of Sulu. *Philippines Journal of Science* 43, 483-500.
- Tanaka, Y. and Kumeta, M. (1981). Successful artificial breeding of the silver-lip pearl oyster, *Pinctada maxima* (Jameson). *Bull. Natl. Res. Inst. Aquaculture* 2: 21 – 28.
- Taylor, J.J., Southgate, P.C. and Rose R.A. (1997). Fouling animals and their effect on the growth of silver-lip pearl oysters, *Pinctada maxima* (Jameson) in suspended culture. *Aquaculture* 153: 42 – 49.
- Taylor, J.J., Southgate, P.C., Rose, R.A. and Keegan, A.J. (1998). Effects of larval set density on subsequent growth and survival of the silver-lip pearl oyster *Pinctada maxima* (Jameson). *Journal of Shellfish Research* 17(1): 281 – 283.

- Travaille K.L., Jones, R. and Wise, B.S. (In Prep.) Ecosystem-Based Fisheries Management (EBFM): Risk Assessment of the Western Australian Silver-Lipped Pearl Oyster (*Pinctada maxima*) Industry. Department of Fisheries, Western Australia.
- Wells, F.E. and Jernakoff, P. (2006). An assessment of the environmental impact of wild harvest pearl aquaculture (*Pinctada maxima*) in Western Australia. *Journal of Shellfish Research* 25(1): 141 – 150.
- Wolf, P.H. and Sprague, V. (1978). An unidentified protistan parasite of the pearl oyster, *Pinctada maxima*, in tropical Australia. *Journal of Invertebrate Pathology* 31: 262 – 263.
- Yu, S. and Brisbout, J. with Tigan, A. (2011). In Mayala country with Aubrey Tigan. Report to Department of Sustainability Energy Water Populations and Communities
- Yukihira, H., Klumpp, D., and Lucas, J. (1998). Effects of body size on suspension feeding and energy budgets of the pearl oysters *Pinctada margaritifera* and *P. maxima*. *Marine Ecology Progress Series* 170: 119-130.

17.2 Principle 1 References (Sections 5 – 9)

- Arnaud-Haond, S., Vonau, V., Bonhomme, F., Boudry, P., Prou, J., Seaman, T., Veyert, M. and Goyard, E. (2003). Spat collection of the pearl oyster (*Pinctada margaritifera cumingii*) in French Polynesia: an evaluation of the potential impact on genetic variability of wild and farmed populations after 20 years of commercial exploitation. *Aquaculture*, 219(1), 181-192.
- Benzie, J. J., and Smith, C. C. (2002). Pearl oyster genetics. FRDC Project 97/344. <http://epubs.aims.gov.au/handle/11068/6365>
- Benzie, J. A., Smith, C., and Sugama, K. (2003). Mitochondrial DNA reveals genetic differentiation between Australian and Indonesian pearl oyster *Pinctada maxima* (Jameson 1901) populations. *Journal of shellfish Research*, 22, 781-787.
- Benzie, J. and Smith, C. (2006). Microsatellite variation in Australian and Indonesian pearl oyster *Pinctada maxima* populations. *Marine Ecology Progress Series* 314: 197-211.
- Department of Fisheries (DoF) (2001). Fisheries Ministerial Policy Guidelines No. 17: Pearl Oyster Fishery; issued pursuant to Section 24 of the Pearling Act 1990.
- DoF (2015). Harvest Strategy Policy for the Aquatic Resources of Western Australia. Fisheries Management Paper 271. Department of Fisheries, Western Australia.
- DoF (2016). Western Australian Silver-lipped Pearl Oyster (*Pinctada maxima*) Resource Harvest Strategy 2016 – 2021. Fisheries Management Paper. Department of Fisheries Western Australia
- ESD Steering Committee (1992). National Strategy for Ecologically Sustainable Development. Endorsed by the Council of Australian Governments, December 1992. ISBN0 644 27253 8.
- Hart, A.M. and Friedman, K.J. (2004). Mother-of-pearl shell (*Pinctada maxima*): stock evaluation for management and future harvesting in Western Australia. FRDC Report - Project 1998/153. Department of Fisheries, Western Australia.
- Hart, A.M. and Joll, L.M. (2006). Growth, mortality, recruitment and sex-ratio in wild stocks of silver-lipped pearl oyster *Pinctada maxima* (Jameson) (Mollusca: Pteriidae), in Western Australia. *Journal of Shellfish Research* 25(1): 201-210.

- Hart, A.M., Thomson, A.W. and Murphy, D. (2011). Environmental influences on stock abundance and fishing power in the silver-lipped pearl oyster fishery. *ICES Journal of Marine Science: Journal du Conseil* 68(3): 444-453.
- Hart, A., Murphy, D. and Jones, R. (2014). Pearl Oyster Managed Fishery Status Report. In: W. Fletcher, and K. Santoro (eds.) Status report of the fisheries and aquatic resources of Western Australia 2013/14: the state of the fisheries. Department of Fisheries WA, Perth, pp. 213 – 218.
- Johnson, M. and Joll, L. (1993). Genetic subdivision of the pearl oyster *Pinctada maxima* (Jameson, 1901)(Mollusca: Pteriidae) in northern Australia. *Marine and Freshwater Research* 44(4): 519-526.
- Lind, C. E. (2009). Population genetics, phylogeography and the effects of aquaculture on genetic diversity of the silver-lipped pearl oyster, *Pinctada maxima* (Jameson) (Doctoral dissertation, James Cook University).
- Lind, C.E., Evans, B.S., Taylor, J.J., and Jerry, D.R. (2007). Population genetics of a marine bivalve, *Pinctada maxima*, throughout the Indo-Australian Archipelago shows differentiation and decreased diversity at range limits. *Molecular ecology*, 16(24), 5193-5203.
- Lind, C.E., Evans, B.S., Elphinstone, M.S., Taylor, J.J., and Jerry, D.R. (2012). Phylogeography of a pearl oyster (*Pinctada maxima*) across the Indo-Australian Archipelago: evidence of strong regional structure and population expansions but no phylogenetic breaks. *Biological Journal of the Linnean Society*, 107(3), 632-646.
- Penn, J.W. and Dybdhal, R. (1988). A research vessel survey of pearl oyster and prawn resources near Broome, Western Australia. (Western Australian Research Lab., North Beach). Fisheries Research Report No. 81, Fisheries Department of Western Australia. 24 pp.
- Rose, R.A. (1990). A manual for the artificial propagation of the silver-lip or gold-lip pearl oyster *Pinctada maxima* (Jameson) from Western Australia. Fisheries Department WA, Marine Research Laboratories, North Beach, WA.
- 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. Final report to the FRDC on Project No. 2010/061. Primary Industries and Regions, South Australia, Adelaide.
- Smith, C., Benzie, J. A. H., and Wilson, K. J. (2003). Isolation and characterization of eight microsatellite loci from silver-lipped pearl oyster *Pinctada maxima*. *Molecular Ecology Notes*, 3(1), 125-127.
- Southgate, P.C. and Lucas, J.S. (2008). *The Pearl Oyster*. Elsevier Science, Amsterdam; London.
- Trevaille K.L., Jones, R. and Wise, B.S. (In Prep.) Ecosystem-Based Fisheries Management (EBFM): Risk Assessment of the Western Australian Silver-Lipped Pearl Oyster (*Pinctada maxima*) Industry. Department of Fisheries, Western Australia.

17.3 Principle 2 References (Sections 10 – 14)

- Apache Energy Northwest Pty Ltd (1998). Chelonia-1 and -2 exploration wells, boundary of Ningaloo Marine Park, North West Shelf. Report and recommendations of the Environmental Protection Authority.
- Bacher, C., Duarte, P., Ferreira, J.G., Heral, M., and Raillard, O. (1998). Assessment and comparison of the Marennes- Ole'ron Bay (France) and Carlingford Lough (Ireland) carrying capacity with ecosystem models. *Aquatic Ecology* 31(4): 379 – 394.
- Baudinet, D., Alliot, E., Berland, B., Grenz, C., Plante-Cuny, M.R., Plante, R., Salen-Picard, C. (1990). Incidence of mussel culture on biogeochemical fluxes at the sediment-water interface. *Hydrobiologia* 207:187 – 196.
- Bejder, M., Johnston, D.W., Smith, J., Friedlaender, A., and Bejder, L. (2015). Embracing conservation success of recovering humpback whale populations: Evaluating the case for downlisting their conservation status in Australia. *Marine Policy* <http://dx.doi.org/10.1016/j.marpol.2015.05.007>
- Bennelongia (2009). Ecological Character Description for Roebuck Bay. Report to the Department of Environment and Conservation. Bennelongia Pty Ltd, Jolimont.
- Blakeway, D. (1997). Scleractinian corals and reef development. In: D. Walker (ed.) *Marine Biological Survey of the Central Kimberley Coast, Western Australia*. Perth: University of Western Australia.
- Bogan, A.E. (1996). *Quadrula quadrula*. The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 17 August 2015.
- Brewer, D., Lyne, V., Skewes, T., and Rothlisberg, P. (2007). Trophic systems of the North West Marine Region. CSIRO, Cleveland: Department of the Environment and Water Resources.
- Brocx, M. and Semeniuk, V. (2011). The global geoheritage significance of the Kimberley Coast, Western Australia. *Journal of the Royal Society of Western Australia* 94: 57 – 88.
- Brown, A.M., Bejder, L., Pollock, K.H., and Allen, S.J. (2014a). Abundance of coastal dolphins in Roebuck Bay, Western Australia: Updated results from 2013 and 2014 sampling periods. Report to WWF-Australia. Murdoch University Cetacean Research Unit, Murdoch University, Western Australia, 32pp.
- Brown, A. M., Kopps, A. M., Allen, S. J., Bejder, L., Littleford-Colquhoun, B., Parra, G. J., Cagnazzi, D., Thiele, D., Palmer, C., and Frere, C. H. (2014b). Population differentiation and hybridisation of Australian snubfin (*Orcaella heinsohni*) and Indo-Pacific humpback (*Sousa chinensis*) dolphins in north-western Australia. *PLoS One*, 9, e101427.
- Bulman, C. (2006). Trophic webs and modelling of Australia's North West Shelf- Technical Report No. 9. North West Shelf Joint Environmental Management Study; CSIRO
- Cappo, M., Syms, C., Stowar, M., Johansson, C., and Cooper, T. (2010). Surveys of fish-habitat associations in the region offshore from James Price Point using Baited Remote Underwater Video Stations (BRUVS). Townsville, Qld: Australian Institute of Marine Science.
- Chapelle, A., Menesguen, A., Deslous-Paoli, J.M., Souchu, P., Mazouni, N., Vaquer, A., Millet, B. (2000). Modelling nitrogen, primary production and oxygen in a

- Mediterranean lagoon. Impact of oysters farming and inputs from the watershed. *Ecological Modelling* 127: 161 – 181.
- Claereboudt, M.R., Bureau, D., Cote, J., and Himmelman, J.H. (1994). Fouling development and its effects on the growth of juvenile scallops (*Placopecten magellanicus*) in suspended culture. *Aquaculture* 121: 327 – 342.
- Claassen, C. (1994). Washboards, pigtoes, and mucklets: historic musseling in the Mississippi watershed. *Historical Archaeology* 28: 1–145.
- Commonwealth of Australia (CoA) (2007). A Characterisation of the Marine Environment of the North-west Marine Region. A summary of an expert workshop convened in Perth, WA, 5-6 September 2007. Canberra: DEWHA.
- CoA (2012). Marine Bioregional Plan for the North-West Marine Bioregion. Canberra ACT: Department of Sustainability, Environment, Water, Population and Communities.
- Cordeiro, J. and Bogan, A. (2012). *Amblema plicata*. The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 17 August 2015.
- Crawford, C.M. (2001). Environmental risk assessment of shellfish farming in Tasmania. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania.
- Crespo, E.A. and Hall, M.A. (2002). Interactions between aquatic mammals and humans in the context of ecosystem management. In: Evans, PGH and Raga, JA (eds.) *Marine Mammals: Biology and Conservation*. Kluwer Academic/Plenum Publishers, New York, pp. 463 – 490.
- Cresswell, I. and Semeniuk, V. (2011). Mangroves of the Kimberley Coast: ecological patterns in a tropical ria coast setting. *Journal of the Royal Society of Western Australia* 94: 213 – 237.
- Cummings, K. and Cordeiro, J. (2011). *Megalonaias nervosa*. The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 17 August 2015.
- Cummings, K. and Cordeiro, J. (2012). *Fusconaia ebena*. The IUCN Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>. Downloaded on 17 August 2015.
- Dame, R., Bushek, D., Allen, D., Lewitus, A., Edwards, D., Koepfler, E., and Gregory, L. (2002). Ecosystem response to bivalve density reduction: management implications. *Aquatic Ecology* 36: 51 – 65.
- Dans, S.L., Crespo, E.A., Garcia, N.A., Reyes, L.M., Pedraza, S.N., and Alonso, M.K. (1997). Incidental mortality of Patagonian dusky dolphins in mid-water trawling: retrospective effects from the early 1980s. *Report of the International Whaling Commission* 47: 699 – 703.
- Daume, S., Fromont, J., and Hart, A. (2009). Management of bioeroding sponges in wild stocks of *Pinctada maxima* in Western Australia. Final FRDC Report – Project 2005/074. Fisheries Research Report No. 196; Department of Fisheries WA. 48 pp. http://www.fish.wa.gov.au/Documents/research_reports/frr196.pdf
- Dawson, C. (1985). Indo-Pacific pipefishes (Red Sea to the Americas). Ocean Springs, Mississippi: Gulf Coast Research Laboratory.

- De Nys, R. and Ison, O. (2004). Evaluation of antifouling products developed for the Australian pearl industry. FRDC Project No. 2000/254.
- Department of Conservation and Land Management (CALM) (2005). Indicative Management Plan for the Dampier Archipelago Marine Park and Preston Marine Management Area. Perth WA: CALM.
- Department of Environment (2006). Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives. Perth: Environmental Protection Authority and the Rangelands NRM Coordinating Group.
- Department of Environment and Conservation (DEC) (2007). Management Plan for the Montebello/Barrow Islands Marine Conservation Reserves 2007 – 2017. Department of Environment and Conservation, Perth, WA.
http://www.dpaw.wa.gov.au/images/documents/parks/management-plans/decarchive/montebello-barrow-mp_final.pdf
- DEC (2008). Preliminary reconnaissance survey of benthic habitats in the Anjo Peninsula area, Kimberley bioregion, Western Australia. Report to the Northern Development Taskforce.
- Department of Environment and Heritage (DEH) (2005). Humpback whale recovery plan, 2005 – 2010. Canberra: National Heritage Trust.
- Department of Environment, Heritage, Water and the Arts (DEWHA) (2008). Marine Bioregional Planning in the North-West. Canberra, ACT.
- Department of Fisheries (DoF) (1998). Fisheries Ministerial Policy Guidelines No. 8: Assessment of Applications for authorisations for Aquaculture and Pearling in coastal waters of Western Australia; issued pursuant to Section 246 of the FRM Act 1994 and Section 24 of the Pearling Act 1990.
- DoF (2001). Fisheries Ministerial Policy Guidelines No. 17: Pearl Oyster Fishery; issued pursuant to Section 24 of the *Pearling Act 1990*.
- DoF (2016). Western Australian Silver-lipped Pearl Oyster (*Pinctada maxima*) Resource Harvest Strategy 2016 – 2021. Fisheries Management Paper. Department of Fisheries Western Australia.
- Department of Parks and Wildlife (DPaW) (2013). Lalang-garram / Camden Sound Marine Park management plan 73 2013 – 2023. Department of Parks and Wildlife, Perth.
- Dharmaraj, S., Chellam, A., and Velayudhan, T.S. (1987). Biofouling, boring and predation of pearl oyster. In: Alagaraswami, K (ed.) CMFRI Bulletin, Vol. 39. Pearl Culture, Central Marine Fisheries Research Institute, Cochin, India. Pp. 92 – 97.
- Doroudi, M.S. (1996). Infestation of the pearl oysters by boring and fouling organisms in the northern Persian Gulf. *Indian Journal of Marine Science* 25: 168 – 169.
- Dybdahl, R. and Pass, D.A. (1985). An investigation of mortality of the pearl oyster, *Pinctada maxima*, in Western Australia. Department of Fisheries WA.
- Enzer Marine Environmental Consulting (1998). The environmental impact of pearling (*Pinctada maxima*) in Western Australia. Report to the Pearl Producers Association, Perth WA.

- Fassler, C.R. (1994). The American mussel crisis: effects on the world pearl industry. *In* Conservation and management of freshwater mussels II. Proceedings of a UMRCC symposium, 16–18 October 1995, St. Louis, Mo. *Edited by* K.S. Cummings, A.C. Buchanan, C.A. Mayer, and T.J. Naimo. Upper Mississippi River Conservation Committee, Rock Island, Ill. pp. 265–277.
- Ferreira, J.G., Duarte, P., and Ball, B. (1998). Trophic capacity of Carlingford Lough for oyster culture — analysis by ecological modelling. *Aquatic Ecology* 31: 361 – 378.
- Fletcher, W. Friedman, K. Weir, V. McCrea, J. and Clark, R. (2006). Pearl Oyster Fishery; ESD Report Series No. 5; Department of Fisheries WA, Perth. 88 pp.
- Fletcher, W.J. and Santoro, K. (2014). Status reports of the fisheries and aquatic resources of Western Australia 2013/14: the state of the fisheries. Department of Fisheries, WA.
- Forrest, B.M., Keeley, N.B., Hopkins, G.A., Webb, S.C., and Clement, D.M. (2009). Bivalve aquaculture in estuaries: review and synthesis of oyster cultivation effects. *Aquaculture* 298(1): 1 – 15.
- Fromont, J., Craig, R., Rawlinson, L., Alder, J. (2005). Excavating sponges that are destructive to farmed pearl oysters in Western Australia. *Aquaculture Research* 36:150 – 162.
- Fry, G., Milton, D., and Wassenberg, T. (2001). The reproductive biology and diet of sea snake bycatch of prawn trawling in northern Australia: characteristics important for assessing the impacts on populations. *Pacific Conservation Biology* 7: 55 – 73.
- Fry, G., Heyward, A., Wassenberg, T., Taranto, T., Stieglitz, T., Colquhoun, J. (2008a). Benthic habitat surveys of potential LNG hub locations in the Kimberley region. Perth: Western Australian Marine Science Institution.
- Fry, G., Heyward, A., Wassenberg, T., Taranto, T., Steiglitz, T., and Colquhoun, J. (2008b) Example preliminary spatial outputs generated from data collected during benthic habitat surveys of four localities in the Canning Marine Bioregion (Gourdon Bay, Quondong- Coulomb Points, Perpendicular/North Heads and Packer Island) in June 2008. Perth, WA: CSIRO and AIMS joint report for WAMSI.
- Fukuda, Y., Whitehead, P., and Boggs, G. (2007). Broad-scale environmental influences on the abundance of saltwater crocodiles (*Crocodylus porosus*), Australia. *Wildlife Research* 34: 167 – 176.
- Gangnery, A., Bacher, C., Buestel, D. (2001). Assessing the production and the impact of cultivated oysters in the Thau lagoon (Mediterranean, France) with a population dynamics model. *Canadian Journal of Fisheries and Aquatic Sciences* 58: 1 – 9.
- Gallardi, D. (2014). Effects of bivalve aquaculture on the environment and their possible mitigation: a review. *Fisheries and Aquaculture Journal* 5: 105 doi: 10.4172/2150-3508.1000105
- Gerritsen, J., Holland, A.F., and Irvine, D.E. (1994). Suspension-feeding bivalves and the fate of primary production: an estuarine model applied to Chesapeake Bay. *Estuaries* 17(2): 403 – 416.
- Gervis, M.H. and Sims, N.A. (1992). *The biology and culture of pearl oysters (Bivalvia: Pteriidae)*. International Center for Living Aquatic Resources Management, Manila. Pp. 20 – 37.

- Gibbs, M.T. (2007). Sustainability performance indicators for suspended bivalve aquaculture activities. *Ecological Indicators* 7: 94 – 107.
- Gifford, S., Dunstan, R., Connor, W., Roberts, T., and Toia, R. (2004). Pearl aquaculture profitable environmental remediation? *The Science of the Total Environment* 319: 27–37.
- Giles, J., Pillans, R., Miller, M. and Salini, J. (2006). Sawfish Catch Data in Northern Australia: a desktop study. CSIRO report for FRDC 2002/064.
- Grant, J., Hatcher, A., Scott, D.B., Pocklington, P., Schafer, C.T., and Winters, G.V. (1995). A multidisciplinary approach to evaluating impacts of shellfish aquaculture on benthic communities. *Estuaries* 18: 124 – 144.
- Guniea, M. (2007). Marine snakes: species profile for the north-western planning area. Northern Territory: DEWHA; Charles Darwin University.
- Hale, J. and Butcher, R. (2009). Ecological Character Description of the Eighty-mile Beach Ramsar Site, Report to the Department of Environment and Conservation, Perth, Western Australia.
- Hall, M.A. and Donovan, G.P. (2002). Environmentalists, fisherman, cetaceans, and fish: is there a balance and can science help to find it? In: Evans, PGH and Raga, JA (eds.) *Marine Mammals: Biology and Conservation*. Kluwer Academic/Plenum Publishers, New York, pp. 491 – 521.
- Harris, J.L. and Milam, C.D. (2002). Field Identification Notebook: Mussels of the White River from Newport to the Arkansas River (v2).
- Hart, A.M. and Friedman, K. (2004). Mother-of Pearl Shell (*Pinctada maxima*): Stock Evaluation for Management and Future Harvesting in Western Australia. FRDC Project 1998/153, Fisheries Research Contract Report No. 10, Department of Fisheries, Western Australia.
- Hatcher, B. (1991). Coral reefs in the Leeuwin Current- an ecological perspective. *Journal of the Royal Society of Western Australia* 74: 115 – 127.
- Hayes, D., Lyne, V., Condie, S., Griffiths, B., Pigot, S., and Hallegraeff, G. (2005). Collation and Analysis of Oceanographic Datasets for National Marine Bioregionalisation. A report to the Australian Government, National Oceans Office. CSIRO Marine Research. 229 pp.
- Hooper, J. and Ekins, M. (2004). Collation and validation of museum collection databases related to the distribution of marine sponges in Northern Australia (Contract National Oceans Office C2004/020). Unpublished Report to the National Oceans Office, Queensland Museum, Brisbane. 206 pp.
- Huang, C.H., Hsing-Juh, L., Huang, T.C., Su, H.M., and Hung, J.J. (2008). Response of phytoplankton and periphyton to system-scale removal of oyster-culture racks from a eutrophic tropical lagoon. *Marine Ecology Progress Series* 358: 1 – 12.
- Hutchins, J. (1994). A survey of the nearshore reef fish fauna of Western Australia's west and south coasts- the Leeuwin Province. Records of the Western Australian Museum.
- IMCRA Technical Group (1998). Interim Marine and Coastal Regionalisation for Australia: An ecosystem-based classification for marine and coastal environments. Canberra: Environment Australia.

- Inglis, G., Hayden, B., and Ross, A. (2000). An overview of factors affecting the carrying capacity of coastal embayments for mussel culture. NIWA Client Report: CHC00/69. 31 pp.
- INPEX Browse Ltd (2008). Environmental scoping/guidelines document for the environmental review and management program and environmental impact statement for the proposed Ichthys gas field development.
- IRC Environment (2002). Environmental effects of pearling (*Pinctada maxima*): Gaps in present knowledge. A report to the Pearl Producers Association Inc. West Perth, WA.
- Jelbart, J.E., Schreider, M., and MacFarlane, G.R. (2011). An investigation of benthic sediments and macrofauna within pearl farms of Western Australia. *Aquaculture* 319: 466 – 478.
- Jenner, K., Jenner, M.N. and McCabe, K. (2001). Geographical and temporal movements of humpback whales in Western Australia. *Australian Petroleum Production and Exploration Association Journal* 41: 749-765.
- Jernakoff, P. (2002). Environmental risk and impact assessment of the pearling industry. Perth: FRDC Project No 2001/099; IRC Environment.
- Johnstone, R. (1990). Mangrove and mangrove birds of Western Australia. WA Museum Supplement 32: 120.
- Kemper, C.M. and Gibbs, S.E. (2001). Dolphin interactions with tuna feedlots at Port Lincoln, South Australia and recommendations for minimising entanglements. *Journal of Cetacean Resource Management* 3: 283 – 292.
- Keesing, J.I., Alderslade, P., Clapin, G., Fromont, J., Hosie, A., Huisman, J., Phillips, J.C., Naughton, K.M., Marsh, L.M., Slack-Smith, S.M., Thomson, D.P., and Watson, J. (2011). Marine benthic flora and fauna of Gourdon Bay and the Dampier Peninsula in the Kimberley region of north-western Australia. *Journal of the Royal Society of Western Australia* 94: 285 – 301.
- Last, P. and Stevens, J. (2009) *Sharks and Rays of Australia*; second edition. Melbourne: CSIRO.
- Lees, B. (1992). Recent terrigenous sedimentation in Joseph Bonaparte Gulf, northwestern Australia. *Marine Geology* 103: 199 – 213.
- Lenanton, R., Joll, L., Penn, J. and Jones, K. (1991). The influence of the Leeuwin Current on coastal fisheries of Western Australia. *Journal of the Royal Society of Western Australia* 74: 101 – 114.
- Lin, H.J., Shao, K.T., Hsieh, H.L., Lo, W.T. and Dai, X.X. (2009). The effects of system-scale removal of oyster-culture racks from Tapong Bay, southwestern Taiwan: model exploration and comparison with field observations. *ICES Journal of Marine Science* 66: 797 – 810.
- Lough, J. (1998). Coastal climate of northwest Australia and comparisons with the Great Barrier Reef: 1960 – 1992. *Coral Reefs* 17: 351 – 367.
- Lourensz, R. (1981). Tropical cyclones in the Australian region, July 1909 to June 1980. Canberra: Department of Science and Technology, Bureau of Meteorology, Australian Government Publishing Service.

- Lourie, S., Foster, S., Cooper, E., and Vincent, A. (2004). A guide to the identification of seahorses. Projects Seahorse; TRAFFIC North America; University of British Columbia; World Wildlife Fund.
- Lourie, S., Vincent, A., and Hall, H. (1999). *Seahorses: an identification guide to the world's species and their conservation*. London: Project Seahorse.
- Lutz, P., Musick, J., and Wyneken, J. (1997). The biology of sea turtles. Boca Raton, Florida: CRC Press.
- Lyne, V., Fuller, M., Last, P., Butler, A., Martin, M., Scott, R. (2006). Ecosystem characterisation of Australia's North West Shelf. North West Shelf Joint Environmental Management Study. CSIRO.
- Markowitz, T.M., Harlin, A.D., Würsig, C., and McFadden, C.J. (2004). Dusky dolphin foraging habitat: overlap with aquaculture in New Zealand. *Aquatic Conservation Marine and Freshwater Ecosystems* 14: 133 – 149.
- Marsh, H., Heinsohn, G. and Marsh, L. (1984). Breeding cycle, life history and population dynamics of the dugong *Dugong dugon* (Sirenia: Dugongidae). *Australian Journal of Zoology* 32: 767 – 788.
- Masini, R., Sim, C., Simpson, C., McKenzie, N., Start, A., Burbidge, A., Kenneally, K.F., and Burrows, N.D. (2009). Protecting the Kimberley: a synthesis of scientific knowledge to support conservation management in the Kimberley region of Western Australia. Perth: Department of Environment and Conservation.
- Mazouni, N., Gaertner, J.C., and Deslous-Paoli, J.M. (2001). Composition of biofouling communities on suspended oyster cultures: an *in situ* study of their interactions with the water column. *Marine Ecology Progress Series* 214: 93 – 102.
- McCallum, B. and Prince, J. (2009) Development of the scientific requirements of an Environmental Management System (EMS) for the pearling (*Pinctada maxima*) industry. Report on FRDC Project No. 2005/044; Pearl Producers Association, WA.
- McCook, L.J., Klumpp, D.W., and McKinnon, A.D. (1995). Seagrass communities in Exmouth Gulf, Western Australia: a preliminary survey. *Journal of the Royal Society of Western Australia* 78: 81 – 87.
- Morgan, G. (1992). Survey of the aquatic fauna of the Kimberley Islands and reefs, Western Australia. Perth: Unpublished report, Western Australian Museum.
- Morgan, D., Whitty, J., and Phillips, N. (2010). *Endangered Sawfishes and River Sharks of Western Australia*. Perth: Woodside Energy Ltd; CFFR Murdoch University.
- Morrison, S., Unsworth, P. and Kangas, M. (2003). A review of the biodiversity of Western Australian soft-bottom habitats in Shark Bay and Exmouth Gulf and the impact of demersal trawl fisheries on benthic communities in Australia. In: Kangas, M.I., Morrison, S., Unsworth, P., Lai, E., Wright, I., Thomson, A. (eds.) Development of biodiversity and habitat monitoring systems for key trawl fisheries in Western Australia. Final report to FRDC on Project No. 2002/038. Fisheries Research Report No. 160; Department of Fisheries, WA, pp. 297-333.
- Niquil, N., Pouvreau, S., Sakka, A., Legendre, L., Addessi, L., Le Borgne, R., Charpy, L., Delesalle, B. (2001). Trophic web and carrying capacity in a pearl oyster farming lagoon (Takapoto, French Polynesia). *Aquatic Living Resources* 14: 165 – 175.

- North West Shelf Joint Environmental Management Study (NWSJEMS) (2007). Final Report NWSJEMS. Perth, WA: CSIRO.
- Northern Development Taskforce (NDT) (2008). Site evaluation report, part B. Department of Industry and Resources.
- Nunes, J.P., Ferreira, J.G., Gazeau, F., Lencart-Silva, J., Zhang, X.L., Zhu, M.Y., and Fang, J.G. (2003). A model for sustainable management of shellfish polyculture in coastal bays. *Aquaculture* 219: 257 – 277.
- O'Connor, W.A., O'Connor, S.J. and Ottoway, N.M. (2003). An examination of the potential for biodeposition from pearl cultivation in Port Stephens. In: O'Connor, W.A., Lawler, N.F. and Heasman, M.P. (eds.) Trial farming the akoya pearl oyster, *Pinctada imbricata*, in Port Stephens, NSW. NSW Fisheries, Nelson Bay, Australia.
- Penn, J.W. and Caputi, N. (1986). Spawning stock-recruitment relationships and environmental influences on the brown tiger prawn (*Penaeus esculentus*) fishery in Exmouth Gulf, Western Australia. *Australian Journal of Marine and Freshwater Research* 37: 491-505.
- Pass, D.A. and Perkins, F.P. (1985). Protistan parasites or residual bodies in *Pinctada maxima*. *Journal of Invertebrate Pathology* 46: 271 – 281.
- Pass, D.A., Dybdahl, R. and Mannion, M.M. (1987). Investigations into the causes of mortality of the pearl oyster, *Pinctada maxima* Jameson, in Western Australia. *Aquaculture* 65: 149 – 169.
- Pass, D.A., Perkins, F.P. and Dybdahl, R. (1988) Virus-like particles in the digestive gland of the pearl oyster *Pinctada maxima*. *Journal of Invertebrate Pathology* 51; 166 – 167.
- PPA (2008a). *Pearling Industry Whale Management Policy and Protocol*. Pearl Producers Association, WA. 10 pp. <http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix4.pdf>
- PPA (2008b). *Pearling in Perspective: an overview of the Australian pearling industry and its environmental credentials*. <http://www.environment.gov.au/system/files/pages/489e726d-1763-4007-8139-32d824d5b55d/files/application-2013-appendix2.pdf>
- Pouvreau, S., Bacher, C., and Heral, M. (2000) Ecophysiological model of growth and reproduction of the black pearl oyster, *Pinctada margaritifera*: potential applications for pearl farming in French Polynesia. *Aquaculture* 186(1 – 2): 117 – 144.
- Prince, R (1994) Status of Western Australian marine turtle populations: The Western Australian marine turtle project 1986-1990. In: James, R (compiler) *Proceedings of the Australian marine turtle conservation workshop*. Queensland Department of Heritage and Australian Nature Conservation Agency. Pp. 1 – 14.
- Prince, J (1999) The effects of farming of the pearl oyster, *Pinctada maxima*, on the benthic infauna in sediments at the Montebellos Islands, Western Australia. No. 773. A Report for Bowman Bishaw and Gorham Environmental Management Consultants.
- Prince, R (2001) Aerial survey of the distribution and abundance of dugongs and associated macroinvertebrates fauna-Pilbara coastal and offshore region, WA. Marine Species Protection Program, Department of Conservation and Land Management.

- Przeslawski, R; Daniell, J; Anderson, T; Vaughn Barrie, J; Heap, A; Hughes, M; . . . Nichol, S (2011) Seabed Habitats and Hazards of the Joseph Bonaparte Gulf and Timor Sea, Northern Australia. Canberra: Geoscience Australia.
- Raillard, O and Menesguen, A (1994) An ecosystem box model for estimating the carrying capacity of a macrotidal shellfish system. *Marine Ecology Progress Series* 115: 117 – 130.
- Roebuck Bay Working Group (2009). Roebuck Bay Ramsar Site Working Plan. Broome, Western Australia.
- RPS (2009) Environment Plan: PGS 2D Seismic Survey: Bonaparte Gulf, Timor and Arafura Seas. West Perth: Petroleum Geoservices.
- Semeniuk, V (1980) Mangrove zonation along an eroding coastline in King Sound, North-Western Australia. *Journal of Ecology* 68: 789 – 812.
- Semeniuk, V (1983) Mangrove distribution in north-western Australia in relationship to regional and local freshwater seepages. *Vegetatio* 53: 11 – 31.
- Semeniuk, V (1985) Development of mangrove habitats along ria shorelines in North and North-Western tropical Australia. *Vegetatio* 60: 3 – 23.
- Semeniuk, V (1997) Selection of mangrove stands for conservation in the Pilbara Region of Western Australia- A discussion 30th June 1997. Perth: Unpublished report to the Department of Resources Development; V and C Semeniuk Research Group.
- Semeniuk, V; Kenneally, K and Wilson, P (1978) *Mangroves of Western Australia*. Handbook of the Western Australian Naturalist Club No. 12.
- Simpson, C. (2011). WAMSI Kimberley Marine Research Program Science Plan. WA: WAMSI.
- Sinclair Knight Merz (2009a) Browse Kimberley LNG Hub- Kimberley Land Council Heritage Clearance Subtidal Survey. Perth, WA.
- SKM (2009b) Port Hedland Outer Harbour Development: Marine benthic habitat survey. Perth, WA.
- SKM (2010) Browse Kimberley LNG Project- Nearshore benthic habitat modelling and mapping, James Price Point. Perth, WA.
- Souchu, P; Vaquer, A; Collos, Y; Landrein, S; Deslous-Paoli, J; and Bibent, B (2001) Influence of shellfish farming activities on the biogeochemical composition of the water column in Thau lagoon. *Marine Ecology Progress Series* 218: 141 – 152.
- Straits Salt Pty Ltd (2006) Yannarie Solar: a Straits Initiative. Environmental Review and Management Programme. Volume 1. West Perth, Western Australia.
- Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC) (2012a) Species group report card — Cetaceans. Canberra: Commonwealth of Australia.
- SEWPaC (2012b) Species group report card — Dugongs. Canberra: Commonwealth of Australia.
- SEWPaC (2012c) Species group report card — marine reptiles. Canberra: Commonwealth of Australia.

- SEWPaC (2012d) Species group report card — seabirds and migratory shorebirds. Canberra: Commonwealth of Australia.
- SEWPaC (2013) *Pristis clavata* in Species Profile and Threats Database. Retrieved from <http://www.environment.gov.au/sprat>
- Takemura, Y and Okutani, T (1955) Notes on animals attached to the shells of the silver-lip oyster, *Pinctada maxima* (Jameson) collected from the ‘East’ fishing ground of the Arafura Sea. *Bulletin of the Japanese Society for the Science of Fish* 21: 92 – 101.
- Thorn, B; Wright, L and Coleman, J (1975) Mangrove ecology and deltaic-estuarine geomorphology: Cambridge Gulf-Ord River, Western Australia. *Journal of Ecology* 63: 203 – 232.
- URS (2008) Cape Preston Benthic Habitats. Perth, WA: CITIC Pacific Mining Management Pty Ltd.
- URS (2009) Ichthys Gas Field Development Project: studies of the offshore marine environment. Perth: INPEX Browse Ltd.
- Veron, JEN and Marsh, LM (1988) Hermatypic Corals of Western Australia. *Records of the Western Australian Museum*, Supplement No. 29. 136 pp.
- Vincent, A (1996) *The International Trade in Seahorses*. Cambridge: Traffic International.
- Walker, D (1995) Seagrasses and Macroalgae. In: F. Wells, R.; Hanley, and D. Walker (eds.) *Marine Biological Survey of the southern Kimberley, Western Australia*. Perth: Western Australian Museum.
- Walker, D and Prince, R (1987) Distribution and geography of seagrass species on the northwest coast of Australia. *Aquatic Botany* 29: 19 – 32.
- Watson-Capp, JJ and Mann, J (2005) The effects of aquaculture on bottlenose dolphin (*Tursiops sp.*) ranging in Shark Bay, Western Australia. *Biological Conservation* 124: 519 – 526.
- Webb, G and Manolis, S (1989) *Crocodiles of Australia*. Sydney: Reed Books.
- Webb, G; Manolis, S; Whitehead, P; Letts, G (1984) A proposal for the transfer of the Australian population of *Crocodylus porosus* Schneider (1801) from Appendix I to Appendix II of CITES. Darwin: Parks and Wildlife Unit, Conservation Commission of the Northern Territory.
- Webb, G; Whitehead, P and Manolis, S (1987) Crocodile management in the Northern Territory of Australia. In: G. Webb, S. Manolis, and P. Whitehead (eds.) *Wildlife Management: Crocodiles and Alligators*. NSW: Surrey Beatty and Sons. pp. 107 – 124.
- Wells, F (1981) The molluscan fauna of the Admiralty Gulf, Cape Voltaire and the Institut Islands, Western Australia. Part I: Chitons, Meso and Neogastropods. In: *Biological Survey of Mitchell Plateau and Admiralty Gulf, Kimberley, Western Australia* (pp. 241 – 263). Perth: Western Australian Museum
- Western Australian Museum (1997) Restricted marine biological survey of the “garden bottom” of Beagle Bay, Kimberley, Western Australia. Western Australian Museum, Perth.
- Wilson, B (1994) Report of the marine parks and reserves selection working group. Perth, WA: Department of Conservation and Land Management.

- Wilson, B and Blake, S (2011) Notes on the origins and biogeomorphology of Montgomery Reef, Kimberley, Western Australia. *Journal of the Royal Society of Western Australia* 94: 107 – 119.
- Wilson, B; Blake, S; Ryan, D and Hacker, J (2011) Macrotidally-dominated, species-rich coral reefs in an enclosed embayment- Talbot Bay, Kimberley, Western Australia. *Journal of the Royal Society of Western Australia* 94: 251 – 256.
- Wolf, P.H. and Sprague, V. (1978). An unidentified protistan parasite of the pearl oyster, *Pinctada maxima*, in tropical Australia. *Journal of Invertebrate Pathology* 31: 262 – 263.
- Woodside Energy Ltd (2001) Proposal to drill an exploration (Thresher-1) in permit area WA-280-P in Joseph Bonaparte Gulf, Published EPBC Referral form. Canberra: Department of Environment and Heritage.
- Würsig, B and Gailey, GA (2002) Marine mammals and aquaculture: conflicts and potential resolutions. In: Stickney, RR and McVay, JP (eds.) *Responsible Marine Aquaculture*. CAP International Press, New York, pp. 45 – 59.
- Yokoyama, H (2002) Impact of fish and pearl farming on the benthic environments in Gokasho Bay: evaluation from seasonal fluctuations of the macrobenthos. *Fisheries Science* 68: 258 – 268.

17.4 Principle 3 References (Sections 15 – 16)

- CoA (1992) National Strategy for Ecologically Sustainable Development. <http://www.environment.gov.au/about-us/esd/publications/national-esd-strategy>
- CoA. (2007). Guidelines for the Ecologically Sustainable Management of Fisheries – v2. 18pp
- Crockford, M. and Jones, B. (2012). Aquatic Animal Health Subprogram: Investigation of Chlamydiales-like organisms in pearl oysters, *Pinctada maxima*. Fisheries Research Report No. 232, Department of Fisheries WA, Perth. 36pp.
- Daume, S., Fromont, J. and Hart, A. (2009). Management of bioeroding sponges in wild stocks of *Pinctada maxima* in Western Australia. Fisheries Research Report No. 196, Department of Fisheries WA, Perth. 44pp.
- DoF. (2012a). Western Australian Government Fisheries Policy Statement March 2012. Department of Fisheries WA, Perth. 12 pp.
- DoF. (2015). Research, Monitoring, Assessment and Development (RMAD) Plan 2015 – 2020. Fisheries Occasional Publication No. 122, Department of Fisheries WA, Perth. 172 pp.
- DoF. (2015). Harvest Strategy Policy and Operational Guidelines for the Aquatic Resources of Western Australia. Fisheries Management Paper No. 271. Department of Fisheries, Western Australia.
- DoF (2016) The *Pearl Oyster Resource Harvest Strategy 2016 – 2021*. Fisheries Management Paper. Department of Fisheries, Western Australia.
- Enzer Marine Environmental Consulting (1998) The environmental impact of pearling (*Pinctada maxima*) in WA, Western Australia.

- Fletcher, W.J. (2005). Application of qualitative risk assessment methodology to prioritise issues for fisheries management *ICES Journal of Marine Research* 62: 1576 – 1587.
- Fletcher, W.J. (2012). National Application of Sustainability Indicators for Australian Fisheries – Part 2: Ecosystem based frameworks for aquaculture, multi-fishery and international applications. FRDC Report – Project 2000/145 Part 2. Fisheries Research Report No. 235, Department of Fisheries WA, Perth.
- Fletcher, W., Chesson, J., Sainsbury, K., Fisher, M., Hundloe, T. and Whitworth, B. (2002). Reporting on Ecologically Sustainable Development: A “how to guide” for fisheries in Australia. Canberra, Australia. 120 pp.
- Fletcher, W.J. and 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, Western Australia.
- Fletcher, W., Friedman, K., Weir, V., McCrea, J. and Clark, R. (2006) Pearl Oyster Fishery ESD Report Series No. 5, Department of Fisheries WA, Perth. 88pp.
- 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.
- Fletcher, W.J.; Shaw, J.; Gaughan, D.J.; Metcalf, S.J. (2011). Ecosystem Based Fisheries Management case study report – West Coast Bioregion. FRR No 225. Department of Fisheries WA, Perth. 116 pp.
- Lulofs, H. and Sumner, N. (2002) Historical diving profiles for pearl oyster divers in Western Australia. Fisheries Research Report No. 138, Department of Fisheries WA, Perth. 20pp.
- McCallum, B. and Prince, J. (2005) Development of the scientific requirements of an Environmental Management System (EMS) for the pearling (*Pinctada maxima*) industry Final FRDC Report 2005/044.
- PPA (2008a) Pearling in Perspective: an overview of the Australian pearling industry and its environmental credentials. 70pp.
- PPA (2008b) Pearling Industry Whale Management Policy and Protocol. 10 pp.
- PPA (2012) Pearl Diving Industry Code of Practice. 49pp.
- Pearling Industry Advisory Committee (2005). Review of Pearl Oyster Hatchery Policy. Phase II. Policy Direction. Fisheries Occasional Publication No 27. Department of Fisheries WA, Perth. 169pp.
- 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. Final report to the FRDC on Project No. 2010/061. Primary Industries and Regions, South Australia, Adelaide.

18. Appendices

Appendix A. Pearl Oyster Translocation Protocol

PEARL OYSTER TRANSLOCATION PROTOCOL

July 2009

(VERSION 9)



PEARL OYSTER TRANSLOCATION PROTOCOL

SCOPE OF PROTOCOL

The purpose of this protocol is to minimise the risks of disease introduction into the Western Australian pearl oyster stocks by the movement of hatchery-produced spat or farmed oysters and to minimise the effects of a disease following the detection of such an event

The protocol governs the movement of hatchery produced pearl oysters and pearl oysters moved between farms. It does not apply to the movement of wildstock shell sourced from the fishing beds within Western Australian pearl fishing zones to farms within Western Australian pearl fishing zones.

OTHER RELEVANT DOCUMENTS

- Pearling (General) regulations 1991
- Pearl Oyster Fishery Ministerial Policy Guideline Section 11.
- Enzootic Diseases Regulations 1970 (EDR) ←
- Fisheries/DEP Translocation MoU

TABLE OF CONTENTS

SECTION 1.....	4
DEFINITIONS.....	4
1.2 GENERAL PRINCIPLES	5
SECTION 2.....	6
2.1 MOVEMENT OF SHELL FROM OUT OF STATE INTO WA.....	6
SECTION 3.....	7
3.1. MOVEMENT OF SHELL WITHIN WA.....	7
4.1 SPAT FROM SEA COLLECTORS	7
4.2. REQUIREMENTS FOR THE SOURCING OR HOLDING OF BROODSTOCK USED IN A HATCHERY.....	8
4.3. HATCHERY SETTLED PEARL OYSTER SPAT	8
4.4. PROCEDURE FOR HEALTH TEST SAMPLING AT HATCHERY:.....	8
4.5. REQUIREMENTS UPON SPAT LEAVING THE HATCHERY	9
4.6 PEARL OYSTER SPAT SUBMITTED FROM A HATCHERY TO A GOVERNMENT FISH PATHOLOGIST FOR HEALTH TESTING.....	10
4.7 PEARL OYSTER SPAT TRANSPORTED FROM HATCHERY TO LEASE SITE. 10	
SECTION 5.....	12
5.1 TRANSLOCATION AND HANDLING OF PEARL OYSTER SHELL WHEN UNUSUALLY HIGH MORTALITY LEVELS INDICATE THERE MAY BE A DISEASE RISK.....	12
5.2 TRANSPORT PROTOCOL Category 1 – All shell transports where no visible signs of sickness. i.e. from regions where high mortality levels have been reported but with no evidence of disease in the farm or lease site of origin.	12
5.3 TRANSPORT PROTOCOL Category 2 – Transport of unhealthy shell. i.e. shell from regions or farms where high mortality levels have been incurred.	12
5.4 TRANSPORT PROTOCOL Category 3 - Spat.....	13
SECTION 6.....	14
6.1 REQUIREMENTS FOR HEALTH TESTING	14
6.2 PROCEDURE FOR THE DESTRUCTION OF PEARL OYSTER SPAT	15
SECTION 7.....	16
7.1 MINIMUM STANDARDS REQUIRED FOR HATCHERY ACCREDITATION	16
7.2 CLEANING/DISINFECTING SCHEDULE.....	17
DISINFECTION OF HATCHERIES WHEN A BATCH FAILS HEALTH CERTIFICATION	18

SECTION 1

DEFINITIONS

Pearl Oyster - means pearl oyster of any of those species of pearl oysters declared under section 6 of the Pearling Act (1990) to be pearl oysters and includes the shell of the pearl oyster and any pearl contained in that shell; the species "*Pinctada maxima*" (Jameson, 1901).

Accredited hatchery - a hatchery for pearl oyster that fulfils minimum engineering and health standards as required under this protocol (and the Pearling general regulations) and which is approved in writing as such by Department of Fisheries.

Batch - means group of spat —

- (a) derived from broodstock brought together for the purpose of spawning; and
- (b) all of which were spawned at approximately the same time and form one settlement.

Broodstock Pearl Oyster - means pearl oysters which are over 120 mm in length and which are, or are intended to be, used for breeding.

Broodstock group - any group of broodstock pearl oysters brought together in a communal aquarium for the purposes of spawning.

Cohort - a group of individuals who share a characteristic acquired at the same time, usually refers to a birth cohort which contains animals born in a specified time period, i.e., pearl oysters which are derived from a particular spawning, a spawning cohort.

Company group - means a group of companies trading as a single corporate entity and recognised by the Department of Fisheries.

Certificate of health - means certificate issued under the Enzootic Diseases Regulations 1970 by a fish pathologist certifying that no clinical disease or significant pathogens were detected in the pearl oysters to which the certificate relates.

Pearl Farm - A pearl farm may be one or more pearl farm leases including any ancillary shore based or floating support facilities that are operated by a licensee as a single productive unit and there is no more than 10 nautical miles between lease boundaries.

Population - all of the animals in a specifically defined area, considered as a whole, i.e., all pearl oysters present on a hatchery pearl farm or holding site.

Settlement - means transition of pearl oysters from planktonic larvae to benthic spat, during which the pearl oysters attach to a substrate by means of byssi;

Spat - means pearl oysters at any stage prior to settlement or which, having settled, are less than the minimum length as defined in the Pearling Act.

Zones 1, 2, 3 and 4 of Western Australia pearl oyster fishery - means the waters as defined in the Pearling (Declaration of zones) Amendment Notice 1997.

1.2 GENERAL PRINCIPLES

- 1.2.1 Records may be kept in electronic format provided a “back-up” system exists to ensure records are not inadvertently deleted.
- 1.2.2 All shell for transport and the panel/container in which shell are to be transported should be cleaned thoroughly prior to transport.
- 1.2.3 Vessels will be subject to strict sanitation and hygiene protocols that meet or exceed the protocols as set in the PPA Code of Practice.

SECTION 2

2.1 MOVEMENT OF SHELL FROM OUT OF STATE INTO WA.

2.1.1 A person shall not import live pearl oysters into the State unless—

- a. the importation is authorized by the Chief Inspector; and
- b. there is a certificate of health in force in relation to the oysters.

SECTION 3

3.1. MOVEMENT OF SHELL WITHIN WA

3.1.1 Wildshell can be moved from the fishing grounds to any lease or pearl farm without health testing provided it has not previously been moved onto a lease or pearl farm.

3.1.2 A person shall not transport pearl oysters —

- (a) out of a hatchery; or
- (b) off any lease or pearl farm to a lease or pearl farm owned by another company group unless there is a certificate of health in force in relation to the pearl oysters, or
- (c) When moving oysters under 90 mm in length from a lease or pearl farm in zone 1 to a lease or pearl farm in any other zone there must be a health certificate in force stating specifically that the intracellular ciliate has not been detected in a sample of 150 oysters taken from the shell to be moved.

The principles here are that all spat coming out of a hatchery have to have a health certificate, and movements between companies will need a certificate in force (see section 4).

3.1.3 Transport vessels maintain a standoff distance of 5 nautical miles from 80 Mile Beach fishing grounds and from active leases operated by other licensees unless agreed in writing by the licensee(s) that the distance from their lease(s) can be less.

3.1.4 Where a 5 nautical mile standoff from leases cannot be achieved due to geographic restrictions or lease concentration, the transport route is to bisect the area between the leases where possible.

4.1 SPAT FROM SEA COLLECTORS

4.1.1 All existing guidelines and legislation regarding the transporting of pearl oysters applies to spat gathered from sea collectors.

4.2. REQUIREMENTS FOR THE SOURCING OR HOLDING OF BROODSTOCK USED IN A HATCHERY.

- 4.2.1 All existing guidelines and legislation regarding the transporting of pearl oysters applies to broodstock.

4.3. HATCHERY SETTLED PEARL OYSTER SPAT

- 4.3.1 Broome office of Department of Fisheries is to be advised within 7 days of any settlement of pearl oyster spat in the form of a Pearl Oyster Settlement Form P9. The company will specify on the form the individual batch number of the spat.
- 4.3.2 The use of antibiotics, except under veterinary prescription, or a Minor Use Permit issued by the Australian Pesticides and Veterinary Medicines Authority, is not permitted.

4.3.1 is used to track progress of batches of spat. DoF need to know if hatcheries suffer "crashes" in spat production.

4.4. PROCEDURE FOR HEALTH TEST SAMPLING AT HATCHERY:

- 4.4.1 Pearl oyster spat from accredited hatcheries shall be reared according to the following protocol in order to be permitted to be imported into WA, or moved within WA.
- 4.4.2 After a successful settlement each batch of spat will be randomly sampled within four days of settlement and every 14 days thereafter, and the samples preserved in formalin seawater (1:9 formalin: seawater) along with a record of the date and batch number. Sample size should be a minimum of 50 individuals. The samples will be stored by the hatchery until the spat have been moved off the quarantine lease or nursery site, or 6 weeks have elapsed since spat leaving hatchery.
- 4.4.3 Samples of a batch of spat from a hatchery may be submitted for examination for a health certificate once the majority of spat are >2mm dorso ventral height. The hatchery manager shall obtain written authority from Department of Fisheries, Broome, to randomly collect 150 spat or such other number as required by the certifying pathologist to conform to the testing confidence level required (95%). The sample is to be treated as required by the certifying pathologist and forwarded to the pathologist by the hatchery manager with a signed certificate (Form No. 11 – Attachment A) detailing the origins of the broodstock and the health standards of the hatchery. The pathologist may also request to sight the logbook relating to the batch to be tested and the hatchery operations logbook over the period of rearing.
- 4.4.4 Departmental staff may choose to supervise the sampling of hatchery pearl oysters to verify the integrity of samples taken.

Note that the number to be tested has reduced from 300 to 150. This is not reflected in the EDR

4.5. REQUIREMENTS UPON SPAT LEAVING THE HATCHERY

- 4.5.1 Each batch of larvae that is grown to settlement will require a health certificate, issued by a pathologist of a government veterinary laboratory, before being moved from the hatchery (Section 4.1.1).

Since hatcheries can be a source of contaminated spat, a mandatory health certificate protects the hatchery,

- 4.5.2 A health certificate is only valid for 2 weeks. If not moved in 2 weeks another health certificate is required. If a health certificate cannot be issued because of the presence of disease, all spat in the batch may be destroyed or subjected to further testing at the discretion of the Chief Inspector of Stock,
- 4.5.3 Where all spat in a batch are to be moved from the hatchery then immediately prior (within 24 hours) to moving certified spat from the hatchery, a random sample of a minimum of 150 spat must be taken and preserved in fixative (10% formalin seawater) to assist the pathologist should any disease appear after leaving the hatchery. The preserved sample, showing batch number and date, is to be held at the hatchery for 6 weeks after spat has left the hatchery. (This sample can be used to check if the hatchery was the origin of an infection subsequently detected in the spat).
- 4.5.4 Where only some spat from a batch are to be moved from the hatchery and a health certificate is in force for that batch, then a random sample is not required while part of the batch (more than 150 animals) remains alive in the hatchery.
- 4.5.5 Any signs of disease in any of the above health tests, may result in destruction or further testing of the batch on the infected site at the discretion of the Chief Inspector of Stock.

**4.6 PEARL OYSTER SPAT SUBMITTED FROM A HATCHERY TO A
GOVERNMENT FISH PATHOLOGIST FOR HEALTH TESTING**

- 4.6.1 Testing is to be carried out as per Section 5 of this protocol
- 4.6.2 Fish pathologist advises the Broome office of Department of Fisheries of the results of the health test within one day of the test being completed (Fax copy of form No 8 to Broome office).
- 4.6.3 Original Certificate of Health Form No8 (*Stock Disease (Regulations) Act 1968*) forwarded onto the Broome office of Department of Fisheries.
- 4.6.4 Duplicate of Certificate of Health Form No 8(*Stock Disease (Regulations) Act 1968*) is retained by Hatchery/Company to accompany transportation.

4.7 PEARL OYSTER SPAT TRANSPORTED FROM HATCHERY TO LEASE SITE.

- 4.7.1 Hatchery submits a Notice of Pearling or Hatchery Activity (pre neap form) Form P2, along with copy of health certificate in force in relation to batch of spat, to the Broome office of the Department of Fisheries, specifying full transport details.
- 4.7.2 Staff of the Broome office of the Department of Fisheries check that a certificate of health is in force in relation to the spat (which are subject to the application to transport).
- 4.7.3 Written authority is then issued to the company for the transportation of oyster spat to take place.
- 4.7.4 The company completes the Transport Log Sheet P6 prior to the transport of oyster spat taking place. The transport log sheet accompanies the transport and is then lodged with the Broome Office within three days of the end of the activity.

4.8 PEARL OYSTERS TRANSPORTED FROM LEASE SITE TO LEASE SITE.

The protocol for obtaining a certificate of health in Western Australia is illustrated in Figure 1.

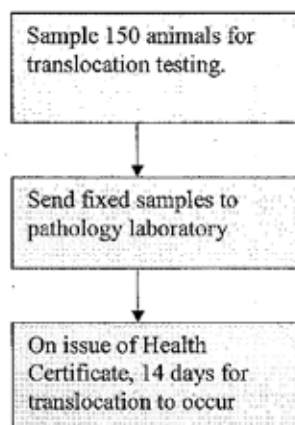


Figure 1. Steps required to obtain a certificate of health. See text for details.

- 4.8.1 Wherever possible, shell to be sampled should be derived from the population destined for translocation and should be biased towards smaller weakened or misshapen individuals. It is acceptable to use the tissues of saibo shell from the same population.
- 4.8.2 Where it is impracticable to sample the shell destined for translocation, because either the number is small or they have been seeded, it is permissible to take the sample from other pearl shell on the lease site. These may be other hatchery shell, wild shell or vomit shell which have been on the site as long as, or longer, than the shell to be translocated. Such an option must be discussed with the certifying pathologist before the sample is taken.
- 4.8.3 A Department of Fisheries Officer may elect to be present when oysters are selected for the health test to ensure the randomness of the sample.
- 4.8.4 All existing guidelines and legislation covering the transport of shell will apply.

SECTION 5

5.1 TRANSLOCATION AND HANDLING OF PEARL OYSTER SHELL WHEN UNUSUALLY HIGH MORTALITY LEVELS INDICATE THERE MAY BE A DISEASE RISK

- 5.1.1. Unusually high mortalities will be reported to the senior fish pathologist and the CEO of Fisheries within 24 hours of discovery.
- 5.1.2 If an unusually high mortality incident is detected, the affected company will apply appropriate processes to mitigate the risk of the mortality spreading to the wildstock shell resource and third party licence holders.
- 5.1.3 Approval to transport shell from farms or leases on which high unexplained mortalities have occurred may only be granted subject to provision of sampling and laboratory examination as described below under Category 2.

5.2 TRANSPORT PROTOCOL Category 1 – All shell transports where no visible signs of sickness. i.e. from regions where high mortality levels have been reported but with no evidence of disease in the farm or lease site of origin.

- 5.2.1 Transport vessels maintain a standoff distance of 5 nautical miles from 80 Mile Beach fishing grounds and from active leases operated by other licensees unless agreed by the licensee that the distance can be less.
- 5.2.2 Where a 5 nautical mile standoff from leases cannot be achieved due to geographic restrictions or lease concentration, the transport route is to bisect the area between the leases.
- 5.2.3 Vessels will be subject to strict sanitation and hygiene protocols that meet or exceed the protocols set out in the PPA Code of Practice..

5.3 TRANSPORT PROTOCOL Category 2 – Transport of unhealthy shell. i.e. shell from regions or farms where high mortality levels have been incurred.

- 5.3.1 Transport vessels maintain a standoff distance of 10 nautical miles from 80 Mile Beach and Lacepede fishing grounds and from active leases operated by other licensees unless agreed by the licensee that the distance can be less.
- 5.3.2 Where a 10 nautical mile standoff from leases cannot be achieved due to geographic restrictions or lease concentration, the transport route is to bisect the area between the leases.
- 5.3.3 If the destination lease is closer than 10 nautical miles from an active lease operated by another licensee, then approval for the transport is required from the active lease licensee.
- 5.3.4 Vessels will be subject to strict sanitation and hygiene protocols that meet or exceed the protocols set in the PPA Code of Practice..
- 5.3.5 To obtain approval to translocate unhealthy shell, the “applicant” must: -

1. Provide sufficient samples of shell for examination and testing as determined by the Department of Fisheries Senior Fish Pathologist (note: examination, testing and the provision of results may take up to 2 weeks from the receipt of samples);
2. Require the licence holders of any and all leases to which the shell is being transported to acknowledge to the Department, in writing, that they are aware that the shell has been subject to an unusually high mortality event;
3. Provide evidence to the Department that they have advised all other licence holders that have current active lease/permit areas or holding sites within 10 nautical miles of the intended steaming route of the intended movement of shell;
4. Acknowledge that, subject to safe navigation, maritime law and geographical restrictions, the steaming route will not pass within 10 nautical miles of defined fishing grounds; and
5. Inform the Department in writing (P2 form) of the intended movement (including the date of transport, where the shell is coming from, where the shell is going to, and the details of the intended steaming route) at least 1 week before it is scheduled to occur.

5.3.6 Any licence holder with a lease, permit or holding area within 10 nautical miles of the site or sites to which the shell is intended to be transported, or within 10 nautical miles of the intended steam route may object to the proposed movement of shell. If the Department receives a written objection, the transport of the shell will not be approved (note that this does not prevent the submission of a further transport request for the same shell which addresses the concerns of objecting third party licence holder/s).

5.3.7 The 10 nautical mile standoff distance is based on current knowledge of the potential spread of waterborne disease and includes a contingency. It is not intended to be a "precedent distance" for all future activity in the pearling industry.

5.4 TRANSPORT PROTOCOL Category 3 - Spat

5.4.1 As per the current translocation protocol.

SECTION 6

HEALTH TESTING

6.1 REQUIREMENTS FOR HEALTH TESTING

6.1.1 Samples collected from each batch or cohort will be subjected to the following tests and examinations by an approved government veterinary laboratory.

a The histological examination of formalin-seawater fixed animals, using haematoxylin and eosin stained longitudinal sections of paraffin embedded tissue.

b Further histochemical stains and electron microscopy at the certifying pathologist's discretion.

c The certifying pathologist can request any further tests or samples taken as deemed necessary.

6.1.2 A health certificate for each batch or cohort will be issued by the government veterinary laboratory subject to the batch or cohort not showing any signs of disease. The presence of any of the following signs of disease or lesions may be reason enough for a health examination certificate not to be issued. It is acknowledged that the following list is not all encompassing, however, it is felt that spat leaving a hatchery should be free of all the organisms and conditions below whereas it is acknowledged that animals from a quarantine lease or nursery site are likely to present some of the points below due to their exposure to the environment.

a The presence of any virus associated with a lesion (eg. inclusion bodies or focal necrosis) or a virus known or suspected to be pathogenic to pearl oysters.

b The presence of any protozoan associated with an inflammatory or degenerative lesion or a protozoan known or suspected to be pathogenic to pearl oysters. (Note: The presence of symbiotic or opportunistic protozoa will not be regarded as a sign of disease)

c The presence of metazoan parasites which cause a lesion in the pearl oysters or which are known or suspected to be pathogenic to pearl oysters.

d The presence of a fungal infection that causes lesions (eg. necrosis/inflammation) in pearl oysters.

e The presence of bacteria associated with lesions or inflammation.

f The presence of rickettsiales associated with lesions or inflammation.

g The presence of unexplained lesions.

h The occurrence of unexplained mortalities in the batch at a level that the certifying pathologist considers unacceptable.

6.1.3 Fish pathologist advises the Broome office of Department of Fisheries of the results of the health test within one day of the test being completed (Fax copy of form No 8 to Broome office).

- 6.1.4 Original Certificate of Health Form No8 (*Stock Disease (Regulations) Act 1968*) forwarded onto the Broome office of Department of Fisheries.
- 6.1.5 Duplicate of Certificate of Health Form No 8(*Stock Disease (Regulations) Act 1968*) is retained by Hatchery/Company to accompany transportation.

6.2 PROCEDURE FOR THE DESTRUCTION OF PEARL OYSTER SPAT

- 6.2.1 Broome office of Department of Fisheries receives notification from the Chief Inspector of Stock via the fish pathologist that a batch of pearl oyster spat has failed the health testing. This notification shall be given within 1 day of the finalisation of the results of the tests.
- 6.2.2 The notification shall be the Certificate of Health Form No 8 (*Stock Disease (Regulations) Act 1968*) faxed to the Broome Office of Department of Fisheries. The Certificate of Health Form No 8 (*Stock Disease (Regulations) Act 1968*) is to be forwarded to the Broome office of Department of Fisheries within 3 days of finalisation of the results of the tests.
- 6.2.3 Within 24 hours of receipt of the faxed advice that the spat failed testing, the Hatchery/Company may be advised by the Chief Inspector of Stock to destroy the entire Batch of spat located in the hatchery or, in the case of a Quarantine lease, the entire stock located on that lease, by incineration or by any other method specified by the Chief Inspector of Stock.
- 6.2.4 The Chief Inspector of Stock with consultation with Department of Fisheries may direct that the entire pearl oysters located on the specific nursery site or quarantine lease be quarantined to enable further health tests or examinations to be undertaken.
- 6.2.5 When an order to destroy stock is received it must be carried out within 24 hours of receiving notice (EDR r 108.2a)
- 6.2.6 Written notification of the destruction of pearl oysters shall be completed by the Hatchery/Company owner and will be forwarded to the Broome office of Department of Fisheries within 3 days of destruction being completed.

SECTION 7

7.1 MINIMUM STANDARDS REQUIRED FOR HATCHERY ACCREDITATION

- 7.1.1 Seawater supplied into the hatchery will be filtered to at least 20µm using duplicate filters. Inlet and outlet seawater pipes to the hatchery will be widely separated to reduce the potential for cross-infection of batches of oysters when more than one batch of oysters is raised at the hatchery at the one time.
- 7.1.2 Seawater used for the production of algal food for larvae must either be autoclaved or filtered to 0.2µm and air supplied to water for algal production for larval food must be filtered to 0.2µm using sterile filters. Utensils used for the production of algal food for larvae must be autoclaved or chemically disinfected.
- 7.1.3 For In-Zone hatcheries, seawater used to rear larvae will be filtered to less than 20µm at the discretion of the operator.
- 7.1.4 For Out of Zone/State hatcheries seawater used to rear larvae will be filtered to 1µm. For this purpose, the zones are 1,2,3 and 4.
- 7.1.5 Seawater used to rear spat, and seawater for the production of algal food for spat, must be filtered to at least 20µm.
- 7.1.6 The hatchery will have facilities to keep batches of spat and different species physically separated.
- 7.1.7 The hatchery will maintain a daily logbook of its' general operations. This will include details of:
 - a Broodstock received by the hatchery
 - b Mechanical operations, including any breakdowns
- 7.1.8 The hatchery will maintain a daily logbook on each batch of larvae/spat. This will include details of:
 - a Estimated numbers of larvae retained at each culling
 - b A regular record of size and stage of larvae
 - c A record of date of first and last day of settlement
 - d A record of estimated numbers of settled spat
 - e A record of estimated numbers of spat at the time of sampling for the health certificate.
- 7.1.9 The hatchery operations logbook and the batch logbooks will be stored and maintained by the hatchery and be available for inspection by the CEO or by a pathologist responsible for issuing a Health Certificate for pearl oyster spat produced in the hatchery.
- 7.1.10 Maintain strict standards of hygiene. These will include:

a. All tanks to be thoroughly cleaned and disinfected after a batch of larvae or spat is removed and before a new batch is placed in them (See cleaning/disinfecting schedule at end of Schedule I).

b. Institute and maintain effective procedures to avoid cross-infections between different batches/species.

7.1.11 Wastewater from hatcheries must be filtered through sand or treated with chlorine or another method of wastewater disposal approved by the Chief Inspector of Stock.

Note: (1) Permits for an accredited hatchery will be obtained annually, subject to satisfactory inspection by an officer approved by Department of Fisheries.

(2) If any unaccountable mortality or signs of clinical disease have been seen either in broodstock pearl oyster or in spat, the accreditation of the hatchery may be suspended and not re-instated until the cause has been investigated and the Fisheries pathologist be satisfied that the facilities meet the criteria for being disease free.

(3) Hatcheries that lose their accreditation, or have been suspended, shall not move spat into or within Western Australia.

7.2 CLEANING/DISINFECTING SCHEDULE

The following cleaning and disinfection schedule will be followed unless the hatchery develops an equivalent schedule and has the schedule approved in writing by a pearling inspector or a stock inspector.

The use of the *AQUAVETPLAN: Operational Procedures Manual -Decontamination* is highly recommended. It provides detailed information on cleaning and disinfection and is available free from

<http://www.daff.gov.au/media/documents/animal-plant/aquatic/aquavetplan/decontamination-manual.pdf>

7.2.1 Cleaning

“Effective cleaning must always precede disinfection. If completed correctly, this step may remove more than 90% of the pathogen loading” (AQUAVETPLAN manual)

All tanks, container's, external pipe surfaces, buckets, nets, boots should undergo a thorough mechanical cleaning using a 1% solution of sodium hydroxide (10g NaOH/litre) at 60°C by means of a brush or high pressure spray.

7.2.2 Disinfection

Following cleaning all tanks and equipment are dried and then disinfected with either an iodophor solution containing 50-100mg/l available iodine or a chlorine solution. With chlorine disinfection, a solution containing 60mg/l available chlorine is to be used, with a contact time of no less than 60 minutes. If the equipment is immersed and soaked, the amount of sodium hypochlorite added must be such that a residual chlorine concentration of at least 10mg/l remains

after 30 minutes. All surfaces must be kept wet with the disinfecting solution during the 60 minutes.

Rinsing

All equipment is to be rinsed free of disinfectant using 1µm filtered seawater or freshwater. For chemically sterilised equipment used for production of larval food, 0.2µm filtered seawater or freshwater is to be used.

Drying

Rinse water is to be drained from all surfaces and the equipment allowed to dry before introducing any new batches of larvae or spat

DISINFECTION OF HATCHERIES WHEN A BATCH FAILS HEALTH CERTIFICATION

Disinfection procedures in a hatchery where a batch fails health certification will be carried out under the direction of a stock inspector or pearling inspector.

ATTACHMENT A: Form No. 11

Stock Diseases (Regulations) Act 1968

**DECLARATION REGARDING
MORTALITY AND DISEASE OF PEARL OYSTERS**

[r.104(5)(b)(ii)]

Name: _____

Address: _____

Phone no: _____

I declare that:

1. The sample of pearl oysters with which this declaration is submitted was taken on _____ from pearl oysters being held at (*location of hatchery, quarantine site etc.*) _____

2. No unexplained mortalities have occurred, and no signs of clinical disease have been seen, in the last 12 months among pearl oysters being held at that place.

Signature _____

Date: _____

Appendix B. Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING

Between the Minister for Fisheries Western Australian Government and the Minister for Primary Industry and Fisheries Northern Territory Government regarding the management of the *Pinctada maxima* Australian South Sea Pearl Industry

Intention

This Memorandum of Understanding (MOU) between the Western Australian (WA) Minister for Fisheries and Northern Territory (NT) Minister for Primary Industry and Fisheries has been developed to ensure that, to the largest extent possible, consistent standards and policies are developed to deal with management, compliance, and industry development including future pearl supply within a total quota framework, and to capitalise on efficiencies and synergies that may be achieved through cooperative arrangements.

Objectives of the MOU

1. To ensure that consistent standards of management and compliance exist within the Australian South Sea pearling industry in WA and NT.
2. To ensure that efficiencies and synergies in pearling management and compliance are achieved through cooperative arrangements.

Scope of the MOU

It is intended that the MOU will evolve as areas of cooperation between NT and WA are explored, within the general scope of the following issues:

- Industry management framework.
- Total 1st operation seeding rights and management framework.
- Translocation and fish health protocols within each jurisdiction and across the border.
- Compliance framework and implementation.
- Market information.

Statements of Agreement between Western Australia and Northern Territory

This MOU is based on the combined agreement between WA and NT of the following:

- That South Sea pearl production being WA and NT should be managed on a "whole of industry" basis in order to maintain the integrity of the industry and its value to the community.
- There are potential synergies and efficiencies in compliance arrangements across both NT and WA.
- Consistent translocation and fish health protocols are critical to the management of both pearl oyster health and production throughout the WA and NT Industry.
- That the collection and interpretation of reliable industry information relating to the South Sea pearl market is an integral input to any future quota management system and volume and timing of variation of quota unit values.

- With the adoption of the Phase III Hatchery Policy, that both jurisdictions progress joint arrangements that facilitate the implementation of that policy.

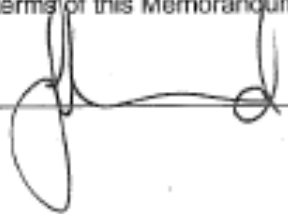
Implementation of the MOU

WA and NT agree to commit to the following processes and action in order to fulfil the objectives of the MOU:

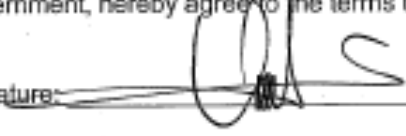
1. NT and WA Governments will align management outcomes to ensure that South Sea pearl production is managed on a 'whole of industry' basis in order to maintain the integrity of the industry and its value to the community.
2. The Western Australian Department of Fisheries Executive Director (or nominee) will have observer rights on the NT Pearling Industry Advisory Committee (NTPIAC).
3. The Northern Territory Department of Primary Industry, Fisheries and Mines Executive Director Fisheries (or nominee) will have observer rights on the WA Pearling Industry Advisory Committee (WAPIAC).
4. An annual meeting will be held between the Executive Directors of the respective Departments, and Chairs of the respective PIACs (and other invited persons) to discuss and coordinate management arrangements amongst the two jurisdictions.
5. The WA Department of Fisheries will report to the NT Department of Primary Industry, Fisheries and Mines, for discussion at NTPIAC, twice yearly on the current issues and activities occurring in the WA pearling industry.
6. The NT Department of Primary Industry, Fisheries and Mines will report to the WA Department of Fisheries, for discussions at WAPIAC, twice yearly on the current issues and activities occurring in the NT pearling industry.
7. WA and NT will consult during the development of jurisdiction specific management arrangements and policies.
8. WA and NT will cooperatively manage increases in total pearl production within each jurisdiction consistent with a total quota framework that ensures maintenance of the integrity of the global markets for Australian South Sea Pearls.
9. WA and NT will implement complementary compliance across both NT and WA.
10. WA and NT will develop consistent translocation and fish health protocols for the management of both pearl oyster health and production throughout the Australian industry.
11. WA and NT will cooperate in the collection of market information that seek to gain an understanding of world pearl markets, and to optimise return to the industry and community.
12. This MOU has an intended term of 10 years and then will be reviewed.

Statement of Agreement

I, Hon Jon Ford JP MLC, Minister for Fisheries Western Australia Government, hereby agree to the terms of this Memorandum of Understanding.

Signature:  Date: 6th June 2006

I, Hon Kon Vatskalis MLA, Minister for Primary Industry and Fisheries Northern Territory Government, hereby agree to the terms of this Memorandum of Understanding.

Signature:  Date: 6/6/06

Appendix C. Licence types



Government of Western Australia
Department of Fisheries

3RD FLOOR, THE ATRIUM
168 ST GEORGES TERRACE
PERTH WESTERN AUSTRALIA 6000
TELEPHONE +61 8 9482 7333
FACSIMILE +61 8 9482 7390
Website <http://www.fish.wa.gov.au>
Email: headoffice@fish.wa.gov.au
wa.gov.au
ABN 55 609 794 771



Fish for the future

Western Australia
Pearling Act 1990
(Section 23 & 26)

Licence No: [REDACTED]

Pearl Oyster Hatchery (Nursery) Licence

Name and Business Address of Licence Holder

Pursuant to section 23 of the Pearling Act 1990 ("the Act"), the Chief Executive Officer hereby issues this hatchery licence to the holder of this licence, to carry out only those hatchery activities described in this licence subject to the Act, Pearling(General) Regulations 1991 ("the Regulations"), and conditions described below.

1. Definitions and interpretations

(a) In this licence the following terms have the meaning they have under the Act or the Regulations-

- (i) "grow out",
- (ii) "nursery site",
- (iii) "spat",
- (iv) "spat collector".

2. Permitted hatchery activities

(a) Grow out

- (i) The grow out, on a nursery site, of spat
- (ii) Moving, dumping, holding, storing or transporting pearl oysters or pearl oyster spat for the purposes of paragraph 2.a.i

(b) Spat collection

- (i) The use of spat collectors as approved in writing by an inspector;
- (ii) Moving, dumping, holding, storing or transporting pearl oysters or pearl oyster spat for the purposes of paragraph 2.b.i



Government of Western Australia
Department of Fisheries

3RD FLOOR, THE ATRIUM
168 ST GEORGES TERRACE
PERTH WESTERN AUSTRALIA 6000
TELEPHONE +61 8 9482 7333
FACSIMILE +61 8 9482 7390
Website <http://www.fish.wa.gov.au>
Email: headoffice@fish.wa.gov.au



Fish for the future

Western Australia
Pearling Act 1990
(Section 23 & 26)

Licence No:

3. **wa. Conditions**
ABN 55 689 794 771

(a) Spat collectors

- (i) A spat collector shall not be used to collect spat unless its use has been approved in writing by an inspector.
- (ii) The maximum number of spat collectors that may be used to take spat shall be approved by an inspector
- (iii) The licensee shall provide to an inspector based at the Broome Regional Fisheries office at least seven days prior written notice of the proposed date, time and place of any harvest of pearl oysters from an approved spat collector(s) and details of the proposed transport to and the destination of the pearl oysters.

(b) General Conditions

- (i) For the purposes of the Regulations, this licence is expressed to be in respect of the hatchery activities specified herein for "hatchery quota", and is aligned to the Pearling Seeding Licence issued to [REDACTED]
- (ii) This licence does not authorise seeding operations on any pearl oysters.
- (iii) Pearl oysters or pearl oyster spat shall only be sold by the licensee to the holder of a pearling licence under the Act or Regulations.
- (iv) No pearl oysters shall be exported from or transported out of Western Australia without prior written authorisation from the Chief Executive Officer.

Period of Licence: Thursday, 1 January 2015 to Thursday, 31 December 2015

File No:

Chief Executive Officer

This licence must be produced to a Fisheries Officer on demand.

WARNING: This licence will have no effect until the imprint of the cash register or other authority is hereon.

Renewal Production - [REDACTED]

**ALL FISHING ACTIVITIES MAY BE SUBJECT TO OPTICAL SURVEILLANCE BY FISHERIES OFFICERS
USING BINOCULARS, TELESCOPES AND NIGHT VISION EQUIPMENT**

Attention

Fisheries legislation changes from time to time. To assist fishers, aquaculturists and members of the public to access fisheries legislation, the Chief Executive Officer has arranged for up to date fisheries legislation to be made available on the internet. Fisheries legislation may be viewed by logging on to the Department of Fisheries website (www.fish.wa.gov.au) and clicking on the Legislation link on the top of the home page. The Chief Executive Officer recommends that the licence holders and persons acting on their behalf (eg. employees), regularly access this legislation service and make themselves aware of the fisheries legislation that relates to their activities.



Government of Western Australia
Department of Fisheries

3RD FLOOR, THE ATRIUM
168 ST GEORGES TERRACE
PERTH WESTERN AUSTRALIA 6000
TELEPHONE +61 8 9482 7333
FACSIMILE +61 8 9482 7330
Website: <http://www.fish.wa.gov.au>
Email: headoffice@fish.wa.gov.au
wa.gov.au
ABN 55 689 794 771



Western Australia
Pearling Act 1990
(Section 23 & 26)

Fee: [REDACTED]

Licence No:

Pearl Oyster Pearling (Seeding Licence) ("Hatchery Quota")

Name and Business Address of Licence Holder

Pursuant to section 23 of the Pearling Act 1990 ("the Act"), the Chief Executive Officer hereby issues this pearling (seeding) licence to the holder of this licence, to carry out only those pearling activities described in this licence subject to the Act, Pearling (General) Regulations 1991 ("the Regulations"), quota and conditions described below.

1 Definitions and Interpretations

(a) In this licence -

- (i) "hatchery quota (WA)" means the maximum number of pearl oysters, other than pearl oysters that have previously been subject to seeding leading to the successful production of pearls, with respect to which seeding operations may be carried out as specified in condition 2(a)(i) of this licence.
- (ii) "hatchery quota (NT pearl oyster fishing/culture licence units)" means the maximum number of pearl oysters, other than pearl oysters that have previously been subject to seeding leading to the successful production of pearls, with respect to which seeding operations may be carried out as specified in condition 2(a)(ii) of this licence.
- (iii) "pearling (seeding) licence", "seeding" and "wildstock" have the same meanings they have under the Regulations.
- (iv) "pearl oyster" has the same meaning as it has under the Act, and is not restricted to - pearl oysters taken under a hatchery (nursery) licence; or pearl oysters grown out on a nursery site operated by the holder of a hatchery (nursery) licence or permit but is restricted to - pearl oysters that were not taken under the authority of a Pearling (Wildstock) Licence during the period 01 January 2015 and 31 December 2015.

2 Quota

- (a) The total number of pearl oysters which may be taken pursuant to section 26(2)(c) of the Act and that may be seeded under this licence is -

Id	Description	Quota Units		Transfer		Quota Value	Supplement (%)	Pearl Oyster Entitlement	
		Held	Suspended	In	Out			Permanent	Current
1	Hatchery Quota - Seeding	[REDACTED]				[REDACTED]		[REDACTED]	[REDACTED]
2	Hatchery Quota (Pearl Production Quality Supplement)						[REDACTED]	[REDACTED]	[REDACTED]

* - Current entitlement is permanent entitlement +/- temporary transfers



Government of Western Australia
Department of Fisheries

3RD FLOOR, THE ATRIUM
168 ST GEORGES TERRACE
PERTH WESTERN AUSTRALIA 6000
TELEPHONE +61 8 9482 7333
FACSIMILE +61 8 9482 7390
Website: <http://www.fish.wa.gov.au>
Email: headoffice@fish.wa.gov.au
www3.gov.au
ABN 55 009 794 771



Fish for the future

Western Australia
Pearling Act 1990
(Section 23 & 26)

Licence No:

Licensed Pearling Activities

- (a) Conducting seeding operations in respect of pearl oysters the subject of hatchery quota;
- (b) Moving, dumping, holding, storing or transporting pearl oysters referred to in paragraph (a);
- (c) Practising, or attempting to practice, pearl culture techniques upon such pearl oysters referred to in paragraph (a);
- (d) Removing or attempting to remove pearls from such pearl oysters referred to in paragraph (a).

4 Transport of Seeded Pearl Oysters Out of WA

- (a) All pearl oysters seeded pursuant to condition 2(a)(ii) of this licence, or an equivalent number of pearl oysters seeded under a Pearling (Wildstock) Licence, shall be transported into the Northern Territory by 31 December 2015.
- (b) The holder of this licence must advise the Department of Fisheries if the number of seeded pearl oysters being transported to the Northern Territory under condition 4(a) is less than the maximum number of pearl oysters able to be seeded under condition 2(a)(ii).

Period of Licence: Thursday, 1 January 2015 to Thursday, 31 December 2015

File No: [REDACTED]

Chief Executive Officer

This licence must be produced to a Fisheries Officer on demand.

WARNING: This licence will have no effect until the imprint of the cash register or other authority is hereon.

Renewal Production - [REDACTED]

**ALL FISHING ACTIVITIES MAY BE SUBJECT TO OPTICAL SURVEILLANCE BY FISHERIES OFFICERS
USING BINOCULARS, TELESCOPES AND NIGHT VISION EQUIPMENT**

Attention

Fisheries legislation changes from time to time. To assist fishers, aquaculturists and members of the public to access fisheries legislation, the Chief Executive Officer has arranged for up to date fisheries legislation to be made available on the internet. Fisheries legislation may be viewed by logging on to the Department of Fisheries website (www.fish.wa.gov.au) and clicking on the Legislation link on the top of the home page. The Chief Executive Officer recommends that the licence holders and persons acting on their behalf (eg. employees), regularly access this legislation service and make themselves aware of the fisheries legislation that relates to their activities.

Page Number 2 of 2 Pages



Government of Western Australia
Department of Fisheries

3RD FLOOR, THE ATRIUM
168 ST GEORGES TERRACE
PERTH WESTERN AUSTRALIA 6000
TELEPHONE +61 8 9482 7333
FACSIMILE +61 8 9482 7390
Website <http://www.fish.wa.gov.au>
Email: headoffice@fish.wa.gov.au
wa.gov.au
ABN 55 669 794 771



Fish for the future

Western Australia
Pearling Act 1990
(Section 23 & 26)

Fee: [REDACTED]

Licence No:

Pearl Oyster Pearling (Wildstock) Licence

Name and Business Address of Licence Holder

Pursuant to section 23 of the Pearling Act 1990 ("the Act"), the Chief Executive Officer hereby issues this pearling (wildstock) licence to the holder of this licence, to carry out only those pearling activities described in this licence subject to the Act, Pearling (General) Regulations 1991 ("the Regulations"), quota and conditions described below.

1 Definitions

(a) In this licence -

- (i) "zone" has the same meaning as it has under the Pearling Act 1990; and
- (ii) "wildstock" has the same meaning as it has under the Regulations.

2 Quota

(a) Subject to condition 3, the total of wildstock pearl oysters which may be taken under this licence is -

Entitlement: *

No.	Description	Quota Units		Transfer		Quota Value	Supplement (%)	Pearl Oyster Entitlement	
		Held	Wildstock (Other)	In	Out			Permanent	Current
1	Wildstock Fishing Quota - Zone 1	[REDACTED]	[REDACTED]			[REDACTED]		[REDACTED]	[REDACTED]
2	Wildstock Zone 1 (Pearl Production Quality Supplement)						[REDACTED]	[REDACTED]	[REDACTED]
3	Wildstock Fishing Quota - Zone 3					[REDACTED]			
4	Wildstock Fishing Quota - Zones 2 & 3	[REDACTED]				[REDACTED]		[REDACTED]	[REDACTED]
5	Wildstock (Pearl Production Quality Supplement)						[REDACTED]	[REDACTED]	[REDACTED]

(or as varied from time to time).

- (b) Pearl Production Quality Supplement aligned to wildstock licence is for seeding purposes only, not capture.
- (c) Any Wildstock (other) aligned to wildstock licence is for seeding purposes only, not capture.



Government of Western Australia
Department of Fisheries

3RD FLOOR, THE ATRIUM
168 ST GEORGES TERRACE
PERTH WESTERN AUSTRALIA 6000
TELEPHONE +61 8 9482 7333
FACSIMILE +61 8 9482 7360
Website <http://www.fish.wa.gov.au>
Email: headoffice@fish.wa.gov.au
wa.gov.au
ABN 55 620 6771



Western Australia
Pearling Act 1990
(Section 23 & 26)

Licence No:

- (a) Pearl oysters which are taken from the wild (as part of the quota specified in condition 2(a) above) may only be taken from the zone/s specified.

4 Licensed pearling activities

- (a) taking, or attempting to take, pearl oysters from the wild;
- (b) removing, or attempting to remove, pearls from wildstock pearl oysters;
- (c) moving, dumping, holding, storing or transporting wildstock pearl oysters, or
- (d) practising, or attempting to practice, pearl culture techniques on wildstock pearl oysters.

Period of Licence: Thursday, 1 January 2015 to Thursday, 31 December 2015

File No:

Chief Executive Officer

This licence must be produced to a Fisheries Officer on demand.

WARNING: This licence will have no effect until the imprint of the cash register or other authority is hereon.

Renewal Production - [REDACTED]

**ALL FISHING ACTIVITIES MAY BE SUBJECT TO OPTICAL SURVEILLANCE BY FISHERIES OFFICERS
USING BINOCULARS, TELESCOPES AND NIGHT VISION EQUIPMENT**

Attention

Fisheries legislation changes from time to time. To assist fishers, aquaculturists and members of the public to access fisheries legislation, the Chief Executive Officer has arranged for up to date fisheries legislation to be made available on the internet. Fisheries legislation may be viewed by logging on to the Department of Fisheries website (www.fish.wa.gov.au) and clicking on the Legislation link on the top of the home page. The Chief Executive Officer recommends that the licence holders and persons acting on their behalf (eg. employees), regularly access this legislation service and make themselves aware of the fisheries legislation that relates to their activities.

Appendix D. Pearl Oyster Farm Lease

PEARLING ACT 1990

PEARL OYSTER FARM LEASE

COMPANY

LEASE SITE

Lease Term: Years

Lease Term Expiry Date: Date Month Year



FISHERIES
WESTERN AUSTRALIA

3rd Floor, the SGIO Atrium, 168 St Georges Terrace, Perth, WA, 6000

Telephone: (08) 9482 7333 Fax: (08) 9482 7389

PEARL OYSTER FARM LEASE

I,, the Director of Aquatic Management, as delegate for the Chief Executive Officer (CEO) within the meaning of the *Pearling Act 1990*, hereby issue a Pearl Oyster Farm Lease under section 23(1) of that Act over the area described in Schedule A ('the leased area'), to the person whose name appears in Schedule B ('the lessee'), being a holder of a licence referred to in Section 23(2) of that Act, for the purposes of conducting pearling activities of the type specified in that licence for the period specified in Schedule C ('lease term') and subject to compliance with the conditions set out in Schedule D ('lease conditions'), the provisions of the *Pearling Act 1990* (and any relevant Ministerial guidelines), and the appropriate fees referred to in Section 27(1)(a) of the Act having been paid.

SCHEDULE A

Lease Area

All that portion of territorial water shown coloured green on Plan No annexed hereto and entitled Lease Site Name.

SCHEDULE B

Lessee

DETAILS

SCHEDULE C

Lease Term

Commencement Date:

Expiry Date:

SCHEDULE D

Lease conditions

1. The lease does not confer exclusive use of the waters upon COMPANY (the lessee) in respect of purposes other than hatchery or pearling activities permitted under the pearling or hatchery licence (as the case may be) held by COMPANY.
2. Access shall be maintained through and within the site at all times for other legitimate uses, including the legitimate activities of native title holders.
3. The lease site shall be marked as a Category (3 or 4) site as defined in the document *“Guidance Statement for Evaluating and Determining Categories of Marking and Lighting for Aquaculture and Pearling Leases/Licences”*. ANY OTHER SPECIFIC REQUIREMENTS.
4. Any flotation buoys used on the longlines must be purpose built, securely attached to the lines and black in colour, or as otherwise approved by the Department of Fisheries.
5. *No anchors and bottom structures shall be placed on, or within swinging distance of, corals and seagrass beds.*
6. The lessee shall undertake monitoring of the benthic habitat at the lease site and any deleterious impacts shall be reported to Department of Environment and Conservation (DEC), through the Department of Fisheries.
7. Any injury or entanglement to rare or protected fauna that occurs within the lease area shall be reported immediately to DEC.
8. The lessee shall not deposit any rubbish, or permit any rubbish or discarded equipment, to remain on site, nor dispose of any rubbish or discarded equipment at sea or on adjacent beaches.
9. The lessee shall bait for rodents at all times, all vessels associated with the pearling operations.
10. On decommissioning, all operational equipment and associated infrastructure must be removed from the site.- not on all lease instruments

.....

DIRECTOR AQUATIC MANAGEMENT

As delegate for the CEO

Dated this

PEARL OYSTER FISHING – DAILY LOG SHEET

Date _____

Trip No. _____

Neap No. _____

(Research Division only)

Driver's No. and name

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

11 _____

12 _____

Licensee _____

Boat Name _____

LPB No. _____

Grid reference	Patch name/No.	Dive No.	Depth (m)	Water temp. surface	Dive time			Pearl oysters taken by diver number												Total mother of pearl oysters (MOP)	Total culture pearl oysters	Total mother of pearl oysters (MOP)	Visiblity in meters	Comments	
					Start	End	Min	1	2	3	4	5	6	7	8	9	10	11	12						
		1																							
		2																							
		3																							
		4																							
		5																							
		6																							
		7																							
		8																							
		9																							
		10																							
		11																							
		12																							
		13																							
		14																							
		15																							
		16																							
Main depth					Totals																				
										TOTAL TODAY										Est. total weight MOP		kg		No. of oysters	

[illegible]

QUOTA RECORD	
Total paid systems taken today	A
Total paid systems taken this year = B Step 1 = Brought forward from previous year + A	B
Total paid systems taken this year = C Brought forward + A	C

MASTER'S DECLARATION

I, _____ the master of this boat certify that:

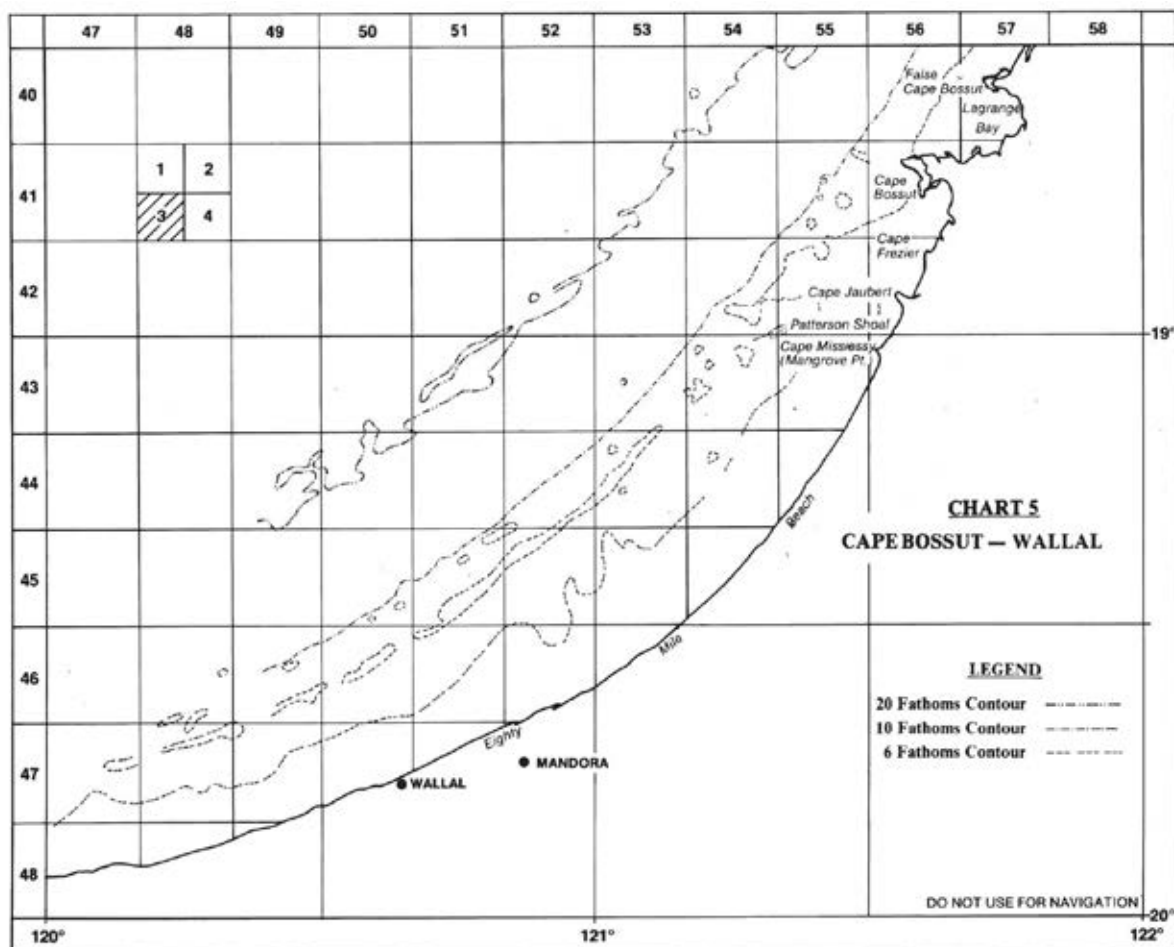
- The information contained herein is true and correct;
- All peacraft activities undertaken on or from this boat have been in accordance with the Peacraft Act and Regulations.

Signature _____ Date _____

WHITE COPY - to Department of Fisheries WA
YELLOW COPY - carrier's copy
PINK COPY - to Fisheries Research Division
GREEN COPY - retain in log book

¹ This column is to record the No. of shell missing from each panel.

Appendix F. Example of statistical reporting grid



Appendix G. Commercial length-frequency monitoring datasheet

PEARL OYSTER LENGTH FREQUENCY SUMMARY SHEET (RESEARCH)											
Date:		Log Inv #:		Date:		Log Inv #:					
Vessel:		Recorder:		Vessel:		Recorder:					
Location:		Grid #:		Location:		Grid #:					
GPS Start:				GPS Start:							
Size Class		Kept		Released		Size Class		Kept		Released	
		Clean	Cliona	Clean	Cliona			Clean	Cliona	Clean	Cliona
	<100						<100				
	100-104						100-104				
	105-109						105-109				
	110-114						110-114				
	115-119						115-119				
A	120-124					A	120-124				
B	125-129					B	125-129				
C	130-134					C	130-134				
D	135-139					D	135-139				
E	140-144					E	140-144				
F	145-149					F	145-149				
G	150-154					G	150-154				
H	155-159					H	155-159				
I	160-164					I	160-164				
J	165-169					J	165-169				
	170-174						170-174				
	175-179						175-179				
	180-184						180-184				
	185-189						185-189				
	190-194						190-194				
	>194						>194				
	TOTALS						TOTALS				
		GRAND TOT:						GRAND TOT:			
		ADDITIONAL COUNTS?						ADDITIONAL COUNTS?			
Comments											

Appendix H. Recruitment and habitat monitoring datasheet

PIGGYBACK SPAT DATA SHEET (RESEARCH)											
Date	Neap Day	Vessel	Recording Officer	Logbook Invoice No							
Drift	Total No. Shell Check	Size (mm) of each Piggy-Back Spat M=Maxima A=Albina O=Others	Total No. Shell Dis. cards	Habitat Type	Vis (m)	Depth (m)	Grid	GPS Mark Start of Drift	Comments	Catch	Recent Wild-Shell Mort. (Y/N)
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Habitat Types: → Garden (light, medium, heavy) — whips, sponges and coral cups → Gn-L, Gn-M, Gn-H
 Asparagus and Potato (light, medium, heavy) — lumpy ascidians → Asp-L, Asp-M, Asp-H, and Pt-L, Pt-M, Pt-H
 Sand and stone — predominantly sand and stone only → Sd, Sn
 Coral & Reef (light, mixed coral, staghorn) — mixed means plates, brains & sand → Cr-L, Cr-M, Cr-H
 Other — e.g. seagrass → Please specify

Appendix I. Whale Management Policy and Protocol

Pearling Industry

Whale Management Policy and Protocol



Pearl Producers Association

First printed in February 2008



Pearl Producers Association Inc
PO Box 55, Mt Hawthorn, WA, 6915
Tel (08) 9492 8822

The Pearl Producers Association would like to acknowledge the contributions of the following organizations.



Department of
Environment and Conservation



INDEX	Page
1. Introduction	3
2. The Pearling Industry	3
3. Pearling Industry Policy on Whale Management	4
4. Benefits of the Pearling Disentanglement Protocol	4
5. Whale Ecology and Movements	5
6. Disentanglement Program Co-ordinated by DEC	6
7. Pearling Whale Interaction Protocol	7
8. Whale Identification Chart	8

Pearling Industry Whale Management Policy and Protocol

1. Introduction

The Pearl Producers Association (PPA) has developed this document in conjunction with the Department of Environment and Conservation (DEC) and the SeaNet Environmental Extension Service, to establish a policy and response protocol to deal with a whale interaction, in the rare event that this should occur.

The PPA has recognised that establishment of a clear course of action for the pearling industry to apply to a whale interaction is a responsible inclusion as part of the Pearling Environmental Code of Conduct.

The PPA acknowledges that whale interactions present complex and often dangerous situations that require specialist skills and training if the whale is to be unharmed, the humans assisting the whale are to be safe in their actions and commercial impact is minimised.

2. The Pearling Industry

The pearling industry described under this policy and protocol is based on the pearl oyster species *Pinctada maxima* conducted throughout the Pilbara, Kimberley and Northern Territory waters of Australia. *P. maxima* is the world's largest pearl oyster. This naturally occurring pearl oyster resource in Western Australia is recognized as the last commercially sustainable pearl oyster fishery in the world.

Pearling is a unique industry in that it operates as a mix of fishing and aquaculture, annually generating around \$200 million in export income.

The Australian Pearl is adjudged the most valuable pearl in the world, prized because of its quality attributes of large size, round shape, smooth complexion, white colour and superior lustre.

Divers collect the pearl oysters by hand from the seabed in waters between NW Cape and Broome under a carefully researched and managed quota system. There are seventeen licensees authorized to harvest wild oysters and carryout round pearl culture in WA.

Pearls are the end result of inserting a seed into the pearl oyster which is naturally smothered with rich pearl nacre produced by the oyster. After two years the pearl has developed to the high quality acceptable to the market and is harvested. Pearl oyster farm sites are situated in sheltered bays and inlets in the region north of Broome (Kimberley Coast) and the Northern Territory coastline.

These sites do not overlap the normal migrating paths of whales along the NT and WA coastline, which are further offshore.

Pearl farm sites are manned at all times - cyclones permitting. Pearl oysters are held in net panels just below the surface, attached to surface longlines which are anchored at each end. The longline system is designed to allow the panels to move with the tide and the oysters to feed in as close as possible to their natural state. The panels are designed to withstand storm surge from cyclones.

Each panel is cleaned every 3-4 weeks using a custom designed cleaning vessel with several crew. There may be several of these machines operating at any time on any farm moving methodically along the longlines during daylight hours. When completing the cleaning of the last shell on the farm they literally commence cleaning the first one again.

3. Pearling Industry Policy on Management of Whale Interaction

The pearling industry commits to the following:

- adopt a cooperative whole of industry approach to preventing interactions,
- adopt an agreed protocol in response to interactions, especially entanglements should they occur, including emergency contact details of appropriate authorities;
- report interactions immediately as rapid reporting ensures response teams have the best possible chance of success;
- monitor on a regular basis all pearling long line systems and mooring ropes to maintain integrity;
- where possible remove any potential sources for entanglement from the marine environment;
- where appropriate and cost effective make use of technological assistance that may reduce the likelihood of an interaction;
- ensure safety of personnel should entanglement occur until trained response teams arrive;
- pearling industry personnel to voluntarily participate in DEC disentanglement training programs to build awareness of procedures and familiarity with disentanglement team personnel. The readiness, local knowledge and vessel handling skills of pearling industry personnel will benefit disentanglement operations.

4. Benefits of the Pearling Industry Whale Interaction Management Protocol

- As a conservation measure to assist in protecting whales from entanglement;
- An established disentanglement network to provide for immediate reporting of incidents so the disentanglement process can begin.
- Industry direct involvement in the reduction of whale interactions by adopting best practice at industry level
- To minimise risks to the incident response team and other personnel.
- Commercial benefits through minimising loss of pearling equipment;

5. Disentanglement Program Co-ordinated by DEC

Rescue operations are conducted according to a recognised response system used for emergency situations in Australia.

DEC applies the 'kegging' technique for entanglements on mobile whales, developed by the Centre for Coastal Studies in eastern USA.

The technique provides a standard operating procedure for attaching lines and heavy buoys to the whale to slow it down, tire it out and keep it on the surface, allowing trained personnel to approach more safely and attempt to remove the entanglement completely.

The entanglement is cut away using specialised designed knives attached to long poles to ensure all rope is removed.

DEC rescue operations will supply trained staff and all equipment for disentanglement program (buoys and special cutting knives).

WHALE ECOLOGY & MOVEMENTS

In Western Australia there are a number of whale species. Wildlife managers believe that whale numbers continue to increase.

Southern Right Whale (*Eubalaena australis*):

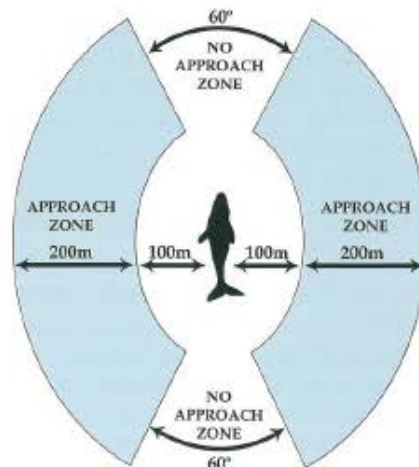
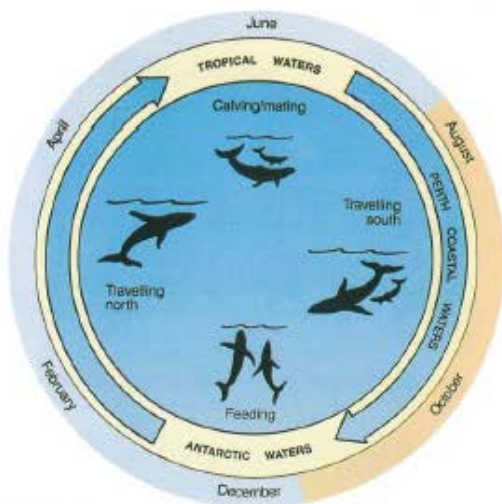
- Slow swimming, migrates through coastal waters, breeds inshore in coastal waters during winter between May to October
- Has rough callosities on head and very long baleen, which could increase the risk of entanglements
- Difficult to disentangle due to uncooperative nature

Humpback Whale (*Megaptera novaeangliae*):

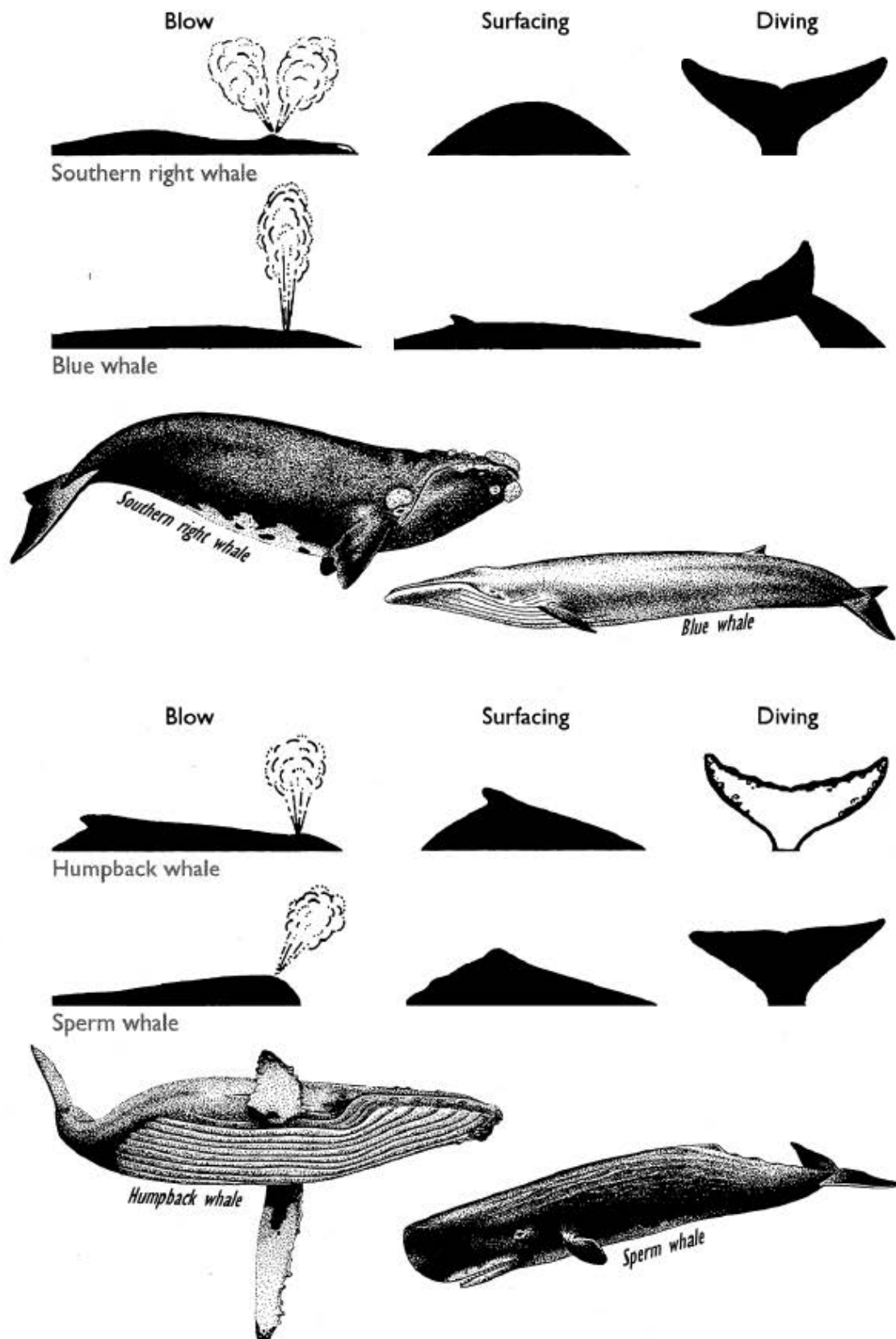
- Migrates through West Australian waters during late May to August returning southward, September to December
- Slow swimming, has very long flippers with knobby leading edges

Blue Whale (*Balaenoptera musculus*):

- Fast streamlined whale which feeds in West Australian waters from December to May
- Danger of entanglement in baleen or flippers while feeding
- Size and power could make it very difficult to rescue.



7. Whale Identification Chart



8. Pearling Industry Whale Interaction Response Protocol

Each pearl farm should nominate an individual who is to be responsible for directing and managing the pearl farm staff response under this protocol.

This responsibility should be formally delegated to another individual in their absence.

Immediate response

- Nominated pearling company individual to initiate this “**Pearling industry whale interaction response protocol**”.
- Refer to established ‘**decision making tree**’ to assess the situation (see immediately below)
- Contact authorities as listed in “**IMPORTANT CONTACT INFORMATION**” (see **immediately below**) to report interaction.
- Take photos and use diagrams that accurately portray the situation to the DEC disentanglement team by email regardless if you make immediate telephone contact.
- Immediately e-mail photos and information to:

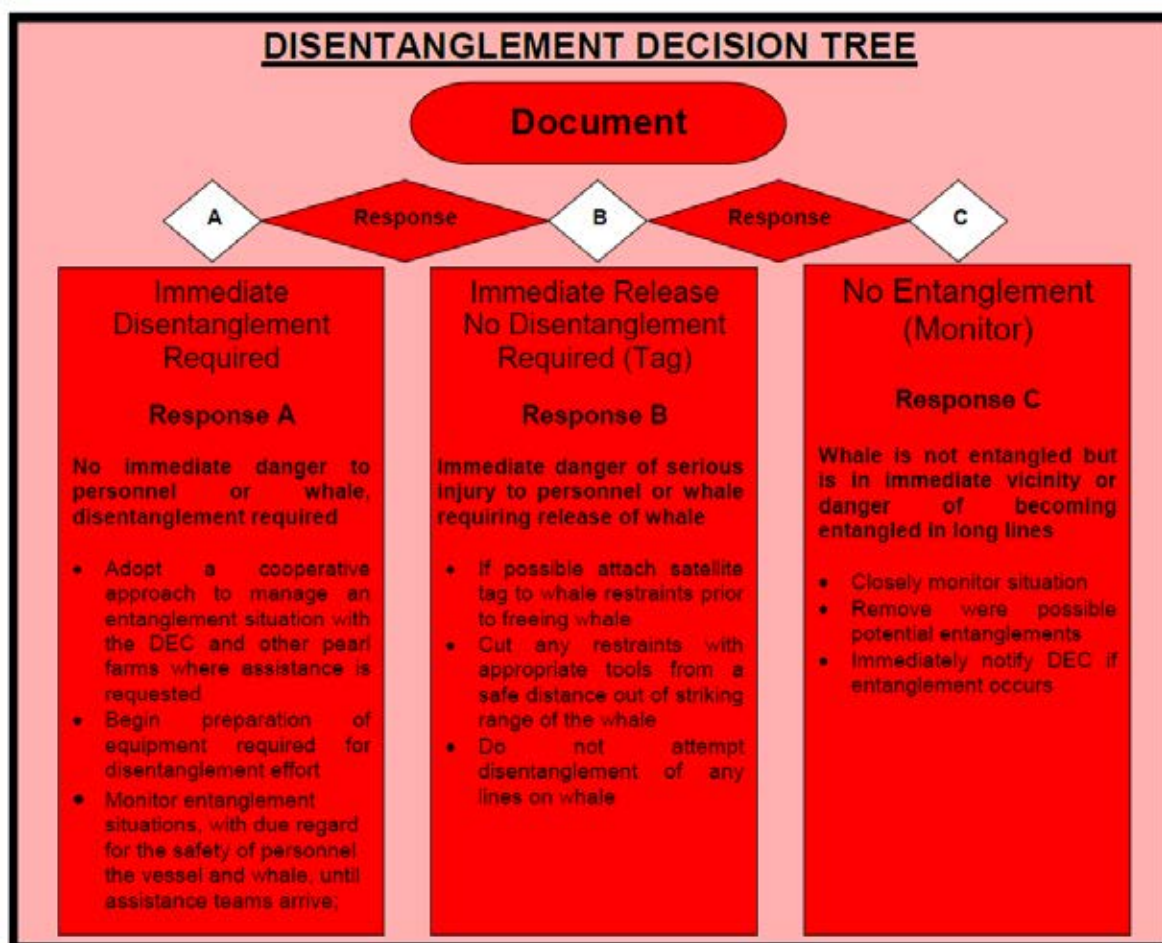
Attention: Doug Coughran douglasc@dec.wa.gov.au

- Standby and wait for directives from the Department Environment & Conservation

IMPORTANT CONTACT INFORMATION.

To notify authorities of an interaction contact (in order of priority):

Department Environment & Conservation (DEC)		
Whale Interaction Co-ordinator	Doug Coughran	0419947708
Department Environment and Conservation (Wildcare)		(08) 9474 9055
Department Environment and Conservation General Enquiries		(08) 9334 0292
Australian Maritime Safety Authority (AMSA)		1800 641 792
Pearl Producers Association		0417 908 089



Appendix J. Invitation to MSC Stakeholder briefing



Department of
Fisheries



The WA Fishing Industry Council, the peak industry body representing commercial fishing, pearling and aquaculture, invites you to a Stakeholder's briefing on the WA Government's \$14.5million initiative to provide every WA commercial fishery the opportunity to be independently certified by the Marine Stewardship Council's (MSC) international gold standard for sustainable fisheries.

Date: Friday March 14, 2014
Time: 9am – 10.30am
Venue: WA Fisheries and Marine Research Laboratories,
39 Northside Drive, Hillarys
RSVP: Monday March 10, 2014 to Jo-Ann Ledger jle88720@bigpond.net.au

The purpose of the briefing is to:

- Outline objectives and progress of the initiative
- Introduce you to the Marine Stewardship Council
- Inspire future partnership opportunities in research, education, tourism, hospitality and NGOs.

Agenda:

- » **The fast facts on the MSC plan for WA**
Mr Arno Verboon, Chair, WA Fishing Industry Council
- » **MSC's mission**
Dr Keith Sainsbury Vice Chair, MSC Board of Trustees
- » **How the plan is rolling out**
Ms Heather Brayford: Deputy Director General, Department of Fisheries
- » **MSC communication partnerships**
Ms Charlotte Connell – Communication Manager Australia and New Zealand
- » **The new partnership: The MSC eco-label, the fisherman, the scientist, the conservationist, the retailer, the chef and the seafood consumer.**
Mr Guy Leyland – MSC Industry Project Leader, WA Fishing Industry Council
- » **Questions**

Background information follows

Supported by



BACKGROUND



DR KEITH SAINSBURY

Dr Keith Sainsbury joined the London based MSC Board of Trustees in 2002 and was appointed Vice Chair in April 2005.

Keith has conducted research on the assessment, ecology, exploitation and conservation of marine resources and ecosystems for over 25 years. Most recently he has focused on multiple-use planning and management of marine ecosystems. He is Professor of Marine System Science at the University of Tasmania, a Commissioner on the Australian Fishery Management Authority, and a strategic advisor to the CSIRO Wealth from Oceans program. Chair of the MSC Technical Advisory Board from 2001 to May 2007.

THE MSC

www.msc.org

The MSC mission is to use our eco-label and fishery certification program to:

1. Contribute to the health of the world's oceans by recognising and rewarding sustainable fishing practices;
2. Influence the choice people make when buying seafood; and
3. Working with our partners to transform the seafood market to a sustainable basis.

The MSC sets two standards:

1. Standard for sustainability fishing
2. Standard for seafood traceability (chain of custody)

The MSC sustainable fishing standard has 3 overarching principles that every fishery must prove that it meets:

PRINCIPLE 1: SUSTAINABLE FISH STOCKS

The fishing activity must be at a level, which is sustainable for the fish population. Any certified fishery must operate so that fishing can continue indefinitely and is not overexploiting the resources.

PRINCIPLE 2: MINIMISING ENVIRONMENTAL IMPACT

Fishing operations should be managed to maintain the structure, productivity, function and diversity of the ecosystem on which the fishery depends.

PRINCIPLE 3: EFFECTIVE MANAGEMENT

The fishery must meet all local, national and international laws and must have a management system in place to respond to changing circumstances and maintain sustainability.

WHY IS THE MSC CHAIN OF CUSTODY STANDARD NEEDED?

To ensure fish sold with the MSC eco-label comes from a certified sustainable fishery

Traceability is a hot topic in the seafood industry. Mislabelling is a recognised problem and the complex international supply chain for most seafood products makes it difficult to find high quality information about the fish source. Ideally, labels on seafood products should provide verifiable information about the species, the source fishery and sustainability information.

Once a fishery has been certified, all companies in the supply chain that wish to handle or sell an MSC certified product not in consumer-ready packaging, must have MSC Chain of Custody certification. This way every link is checked to make sure the MSC label is only displayed on seafood from a MSC certified sustainable fishery.

FAST MSC FACTS

- Almost 11% of the world's total allowable catch is engaged in the MSC program.
- MSC sets a standard for sustainable fishing and seafood traceability. Third-party independent bodies assess the fisheries.
- Every McDonald's Fillet-O-Fish burger sold in America is now MSC certified.
- Almost all of the McDonald outlets in Europe are involved in the MSC program.
- Germany now sells more than 5,000 MSC certified products in its supermarkets.
- Coles and Woolworths have both made commitments to source MSC certified seafood.
- MSC is an international non-profit organisation based in London.

Appendix K. Notice of Pearling or Hatchery Activity Form (P2)

16

NOTICE OF PEARLING OR HATCHERY ACTIVITY - FORM P2 (Pre Neap Form)

(To be completed and submitted prior to any taking, transporting, or operating of pearl oysters)

Licensee (full name of licensee):								
Pearl Oyster fishing details for the period: From To								
Boat	Boat Name	Boat No.	Master	Port of Departure	Date of Departure	Fishing Period	Area to be fished	Date of return
1								
2								
3								
4								
5								
Fleet Master:								
Comments:								

Pearl oyster/spat transportation details for the period: From..... To								
Trip	Date of Transport	Boat / Plane Vehicle No	Boat / Plane Name	Source / of shell to be transported	Location to be transported	Number shells to be transported (indicate if tagged or untagged*)	Destination	Estimated time and date of arrival
1								
2								
3								
4								
5								
Comments:								

* Please ensure authorisation is received from Broome Office prior to transportation of untagged oysters.
If the pearl oysters you intend transporting are hatchery produced, please indicate size range

NOTICE OF PEARLING OR HATCHERY ACTIVITY - FORM P2
(Pre Neap Form)

Pearl oyster seeding details for the period: From: To:

Boat	Operation Boat Name	Boat No.	Master	Number of shell	Holding site / farm	Period of Date from	Seeding	Operation Date to
1							-	
2							-	
3							-	
4							-	

Disease sampling of Broodstock / Spat: Date: Vet Pathologist

Batch No	B/stock/spat No	Date Spawn	Date Settled	Broodstock Tag No.				
1								
2								
3								
4								

Details of other hatchery / pearling activity:

Declaration: I / We certify that the information contained
(Licensee)
herein is true and correct.

Signature: Date:

Signature: Date:

Signature: Date:

Q:\pearlformp2.xls

Western Australian Marine Stewardship Council Report Series No.5, 2016

[illegible]

Appendix M. Certificate of Health

Form No. 12

2015-122

Stock Diseases (Regulations) Act 1968

CERTIFICATE OF HEALTH - PEARL OYSTERS

Name: Fran Stephens

Address: Department of Fisheries, Fish Health Unit
3 Baron-Hay Court, SOUTH PERTH, WA 6151

Phone no: 08 9368 3649

I am an approved fish pathologist and certify that:

1. This certificate has been issued in respect of a sample of pearl oysters marked
which was taken from pearl oysters being held at (*location of hatchery, quarantine site etc.*)

The sample was delivered to me for disease testing on
by courier.

2. I have no reason to doubt the information given as to the origins of the pearl oysters or the levels of mortality or clinical disease in the hatchery, quarantine site or other place where the pearl oysters are being held.

3. The following tests were carried out for clinical disease or significant pathogens

Test	Number tested	Date	Result

4. No clinical disease or significant pathogen was detected in the sample

Signature: Fran Stephens

Approved fish pathologist


Date: _____

OFFICE USE ONLY

1. AHL No:

2. Name of Licencee or Permit Holder Fish Health

Appendix N. Daily Patrol Contacts Form



FMO Daily Patrol Commercial Contacts Form

Page of

District:

Date: / /

Reporting FMO:

Covert Initially: Y / N

Commercial Information					Quota Information				TPF		Outcomes							
INSP TIME (24h)	LFB # or Lic #	Licence Checks	Gear Checks	Amount Of Gear	Boat Search	Bag Checks	Initial Insp Loc Code	Nbr Containers Insp	CDR / Consignment #	Containers		Independent Weight Checks	Scale Verification	Weighing Location	TPF Check	#TPF	Compliant?	Comments
										Weight Checks	Security Checks							
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>	
		<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>					<input type="checkbox"/>							

