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Resource Assessment Report Western Rock Lobster Environmental Resources of Western Australia

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Resource Assessment Report Western Rock Lobster Environmental Resources of Western Australia

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Preface

This document presents information for the Western Rock Lobster Fishery for MSC re-certification process in 2017. For historical information relevant to the previous assessment and additional background information refer to Bellchambers LM, Mantel P, Pember MB and Evans SN. (2012) Western Rock Lobster State of the Knowledge. Fisheries Research Report No. 236. Department of fisheries Western Australia.

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1 Background to the West Coast Rock Lobster Managed Fishery

This section provides a brief synopsis of salient information pertinent to assessing the ecological components of the West Coast Rock Lobster Managed Fishery (WCRLF). For full details on the biology and environmental conditions impact on this, the stock assessment and information on the commercial and recreational components of the fishery please refer to de Lestang et al. (in press).

1.1 Biology and Distribution

1.1.1 Distribution

The western rock lobster *Panulirus cygnus* (George 1962) is found in temperate waters off the west coast of Western Australia where juveniles populate shallow inshore reefs (< 40 m depth) and adults (> 80 mm carapace length) populate deep-water offshore habitats (> 40 m depth) including the coral reefs at the Houtman Abrolhos Islands (Abrolhos Islands). Its area of distribution is the continental shelf on the west coast of Western Australia, with greater abundances off the mid-west coast (Geraldton – Perth) than the northern and southern parts of the west coast (Figure 1.1).

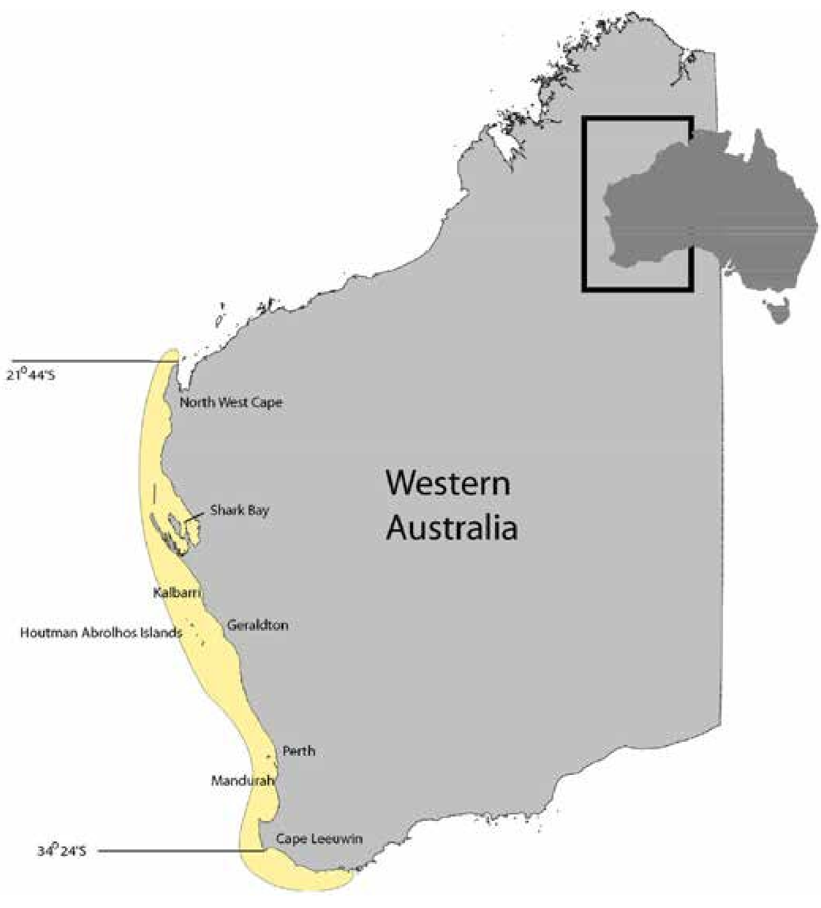

Figure 1.1 Distribution of the western rock lobster (*Panulirus cygnus)* along the Western Australian coastline.

The eastern Indian Ocean, which abuts the Western Australian coastline, is dominated by the warm, southward-flowing, tropical water of the Leeuwin Current. In contrast, the Capes Current runs inshore of the Leeuwin Current and when pushed by strong south westerly winds during the summer months, causes cool, high-salinity water to flow northwards along the coast. Thus, the western rock lobster (WRL) experiences a large annual temperature range across its distribution from around 27°C at North West Cape in February to 16°C near Cape Leeuwin in August.

1.1.2 Life History

The WRL typically lives for about 20 years and weighs less than 3 kg. The mating system involves the male attaching a package of sperm called a tarspot to the female's sternum. At spawning, the female releases eggs from small pores at the base of the third pair of walking legs. When the female scratches the tarspot, sperm is released and the eggs are fertilised as they are swept backwards and become attached to the sticky setae on the pleopods. After successful external fertilisation, the female will carry and care for the egg brood attached to her abdomen for a period of 5-8 weeks. The number of eggs produced by a female during a spawning period depends on the size of the individual (Chubb 1991). Hence, larger females produce more eggs per unit size than smaller females, with large females capable of producing up to a million eggs (Morgan 1972), and have a greater likelihood of spawning twice in a season (Melville-Smith and de Lestang 2006).

Upon hatching, the tiny larvae called phyllosoma spend 9-11 months as plankton in the water column driven by ocean currents. After several moults, the phyllosoma larvae moult into the free-living puerulus stage and swim towards the coast to settle among seagrass beds and algal meadows (Figure 1.2). The settlement of puerulus occurs throughout the year, with peaks from late-winter to mid-summer, although the rate of settlement of puerulus can vary greatly from year to year and is largely driven by environmental factors (Caputi *et al.* 2000). For example, when the Leeuwin Current is flowing strongly, the settlement of puerulus is high and a higher proportion of the larval WRL return to the coast. The effects of climate change on puerulus settlement, WRL catchability, movement and moulting patterns are currently being monitored (Caputi et al. 2010b and 2015).

After they moult into the juvenile stage the WRL are more prevalent on inshore reefs where they spend the next 3-4 years feeding and growing. When they reach a size of around 70-80 mm carapace length, many WRL undergo a synchronised moult event, known as 'whites moult', as their new shell is paler than their normal bright red colour. The 'white' phase coincides with the WRL migratory phase, when they leave the coastal reefs and make a mass migration across sandy habitats to their deep-water, offshore breeding grounds. When the 'whites' reach the offshore breeding grounds, they settle and slowly their shell returns to their normal red shell colour and remain in the deep-water habitats.

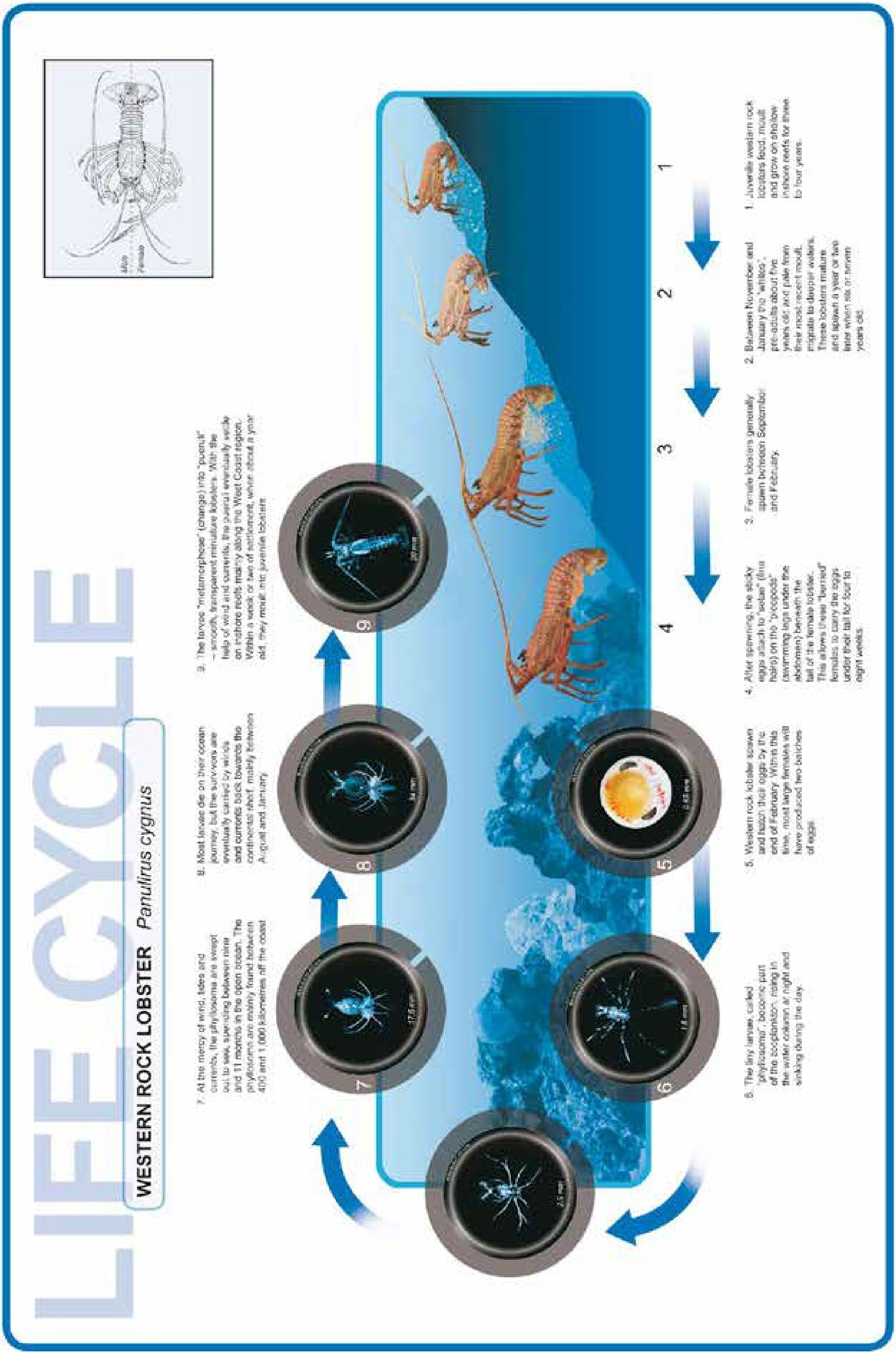

Figure 1.2 Life history of the western rock lobster (*Panulirus cygnus)* (Source: Department of Fisheries 2011).

1.1.3 Growth

Factors such as temperature, photoperiod, oxygen availability, diet, lobster density, limb damage and reproductive phase can all influence the growth rate of the WRL (Chittleborough 1975). There is considerable spatial variation in the reproductive biology and growth of male and female WRL throughout the fishery. In the cold-water southern areas of its distribution, WRL are mature at about 6-7 years or around 90 mm carapace length. In the warmer northern waters near Kalbarri and the Abrolhos Islands they mature at smaller sizes, usually at about 70 mm carapace length (Melville-Smith and de Lestang 2006). The growth rate of WRL is faster in warmer waters towards the northern end of the fishery than in the south (de Lestang *et al*. 2009) this has been attributed to increased moult frequency rather than larger moult increments (Chittleborough 1975).

1.2 Management

The commercial West Coast Rock Lobster Managed Fishery (WCRLF) operates from shallow inshore regions to the edge of the continental shelf. Historically, the primary management methods were input controls with limits on the number of licensees and the total number of pots that could operate in the fishery. However, in 2009/10 the fishery switched from input controls to a Total Allowable Commercial Catch (TACC). The WRL is also a popular recreational species. Around 45 000 recreational WRL licenses are issued annually, and approximately 50 % of them are used. Most of the recreational fishing is focused around Perth and Geraldton. Several restrictions apply to the recreational capture of WRL including the number of pots-per-licence, pot design, bag limits, and allowable fishing areas and periods. The WCRLF has undergone the Integrated Fisheries Management (IFM) process, with Total Allowable Catch allocated as 95 % to the commercial sector, 5 % to the recreational sector and one tonne to customary fishers (IFAAC 2007; de Lestang *et al.* 2010b).

The commercial fishery is managed in three zones: south of latitude 30°S (Zone C), north of latitude 30°S (Zone B) and a third offshore zone (Zone A) around the Abrolhos Islands (Figure 1.3). The only allowable method of capture commercially is the use of baited pots fitted with escape gaps (for undersized lobsters (<76 mm carapace length) and bycatch). Pots are retrieved with the captured lobsters of legal size and appropriate reproductive status (e.g. not berried) placed into holding tanks and returned to on-shore processing plants, where the majority are prepared for live shipments to export markets, predominantly China.

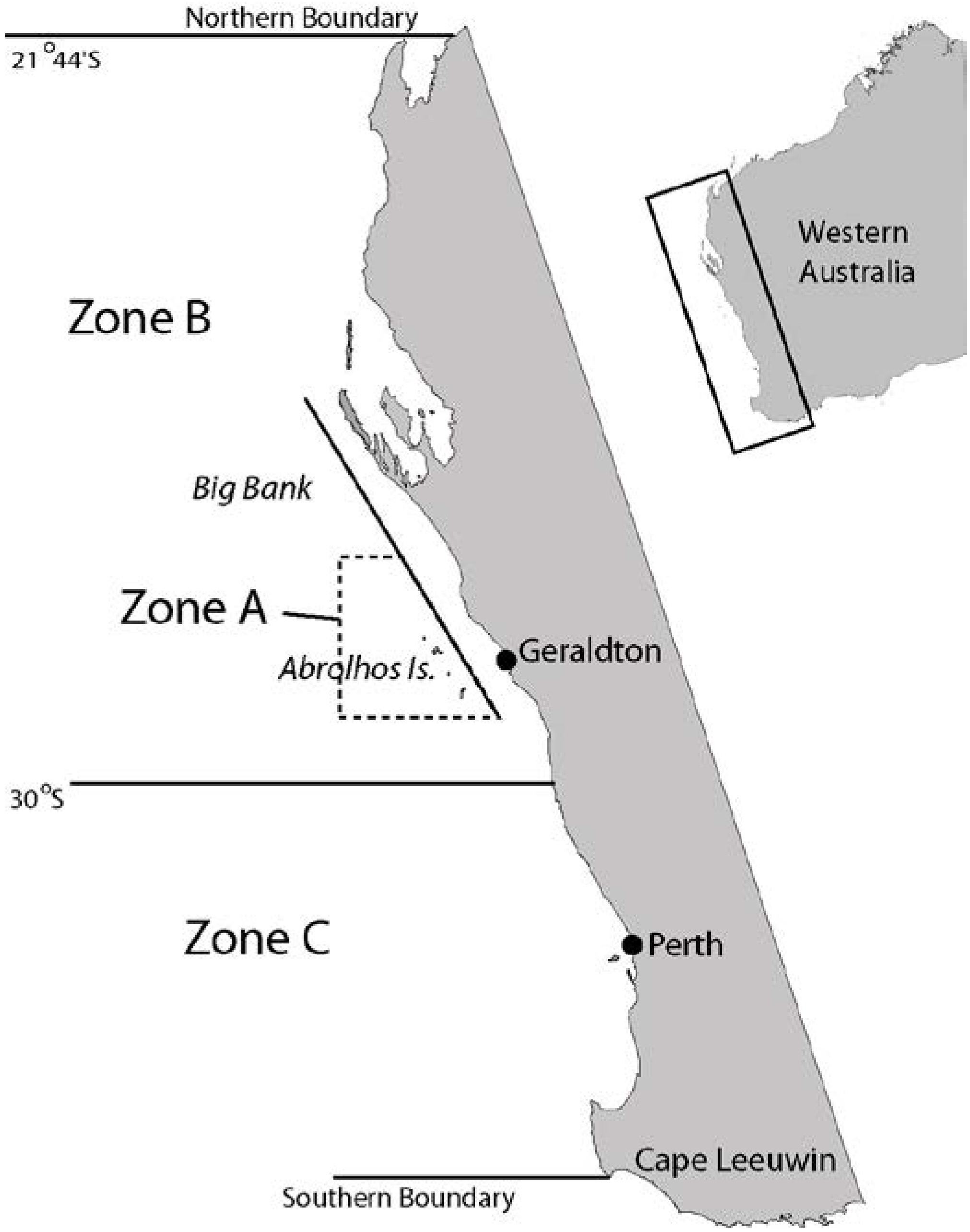

Figure 1.3 West Coast Rock Lobster Managed Fishery Management Zones

1.3 Marine Stewardship Council Certification

The Marine Stewardship Council (MSC) is an international non-profit organisation dedicated to promoting sustainable fisheries. The MSC certification process involves independent third-party assessments, conducted by Conformity Assessment Bodies (CABs), of a fishery against the MSC fisheries standard known as the Fisheries Assessment Methodology (FAM). The FAM has three broad principles; 1 - sustainable target fish stocks, 2 - environmental impacts of fishing and 3 – effective governance with each principle comprised of a series of performance indicators (PIs) against which the fishery is scored.

The WCRLF was the first fishery certified by MSC in 2000 and has since been re-certified in 2006 and 2012 (see. Bellchambers et al. (2012, 2014, 2015) for details).

1.4 Ecological Risk Assessment (ERA)

ERAs were conducted in 2001 (IRC Environment 2009), 2005 (Burgman 2005), 2007 (Stoklosa 2007) and 2013 (Stoklosa 2013), to provide a register of the potential ecological risks that may arise from activities carried out by the fishery and to identify management strategies to control risk where necessary (see Bellchambers *et al.* 2014 for summary).

1.5 Environmental Management Strategy

The Environmental Management Strategy (EMS) was developed to provide objectives, targets and management actions to deal with hazards identified as risks from the ERA process. The first EMS covered the period July 2002 to July 2006 and the second was for the period July 2010 to June 2015 (Brown and How 2011). Currently all the hazards identified by the ERAs have been resolved or mitigated such as ecological effects of fishing (Section 6), Australian sea lions with sea lion exclusion devices (SLEDS) (Section 4.1), dusky whaler sharks and bait bands (Section 4.3), as well as whale entanglement mitigation (Section 4.2), therefore currently no stand-alone future EMS will be produced. Issues that arise will be dealt with on a case by case basis.

2 Retained and Bycatch species

2.1 Methods

Rock lobster pots are effective at catching rock lobsters, but catch very few other species.

However, WRL fishers are permitted to retain all species of rock lobsters (not just *Panulirus cygnus*) caught in pots and can also retain and sell octopus (no maximum amount) and deep sea crabs (maximum of 12 per day)[1]. Under the West Coast Demersal Scalefish Managed Fishery Interim Management Plan (Clause 24.2.b)[2] WRL fishers are permitted to retain scalefish/finfish taken as bycatch in pots for personal consumption only (i.e. not for commercial purposes). Weights of all species retained as catch are recorded in statutory catch disposal records (CDRs) completed after each fishing trip, which have been in place in their current form for the last three seasons (i.e. 2013 onwards).

Details of fish and invertebrate bycatch species caught during normal fishing operations are also recorded as part of on-board commercial monitoring. Monitoring of commercial catch occurs at seven locations throughout the fishery (Figure 2.1), with lobsters measured and non-target species recorded in each of four depth categories (0-9, 10-19, 20-29 and 30+ fathoms) each month (for details see de Lestang *et al.* in press). Non-target species are recorded as retained, returned alive or returned dead, along with number of pots sampled. Catch rates of non-target species are then generated from these data.

Catch rates (*n*/potlift) of non-target species recorded during commercial monitoring are scaled up to a fishery-wide estimate. Effort and depth are recorded in 10x10 nautical mile from the CDRs. The 10x10 nm blocks are then ascribed to a port where monitoring occurs (Figure 2.1). The fishing effort from these ports by depth category is then used to provide the effort which is multiplied by the species catch rates.

[1]For Clause 28 (3) of the WCRLMF Management Plan that deals with deepsea crabs see: https://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/2B3A7C7BF6ED718D48257FBD00218A24/$file/43.8+wcrlmfmp+2012+-+24.05.16.pdf

[2]For Clause 24.2.b of the west coast demersal interim management plan see: https://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/CE35B4889B1C5D0148257E9E00236105/$file/39.15+west+coast+demersal+scalefish+-+11.08.15.pdf

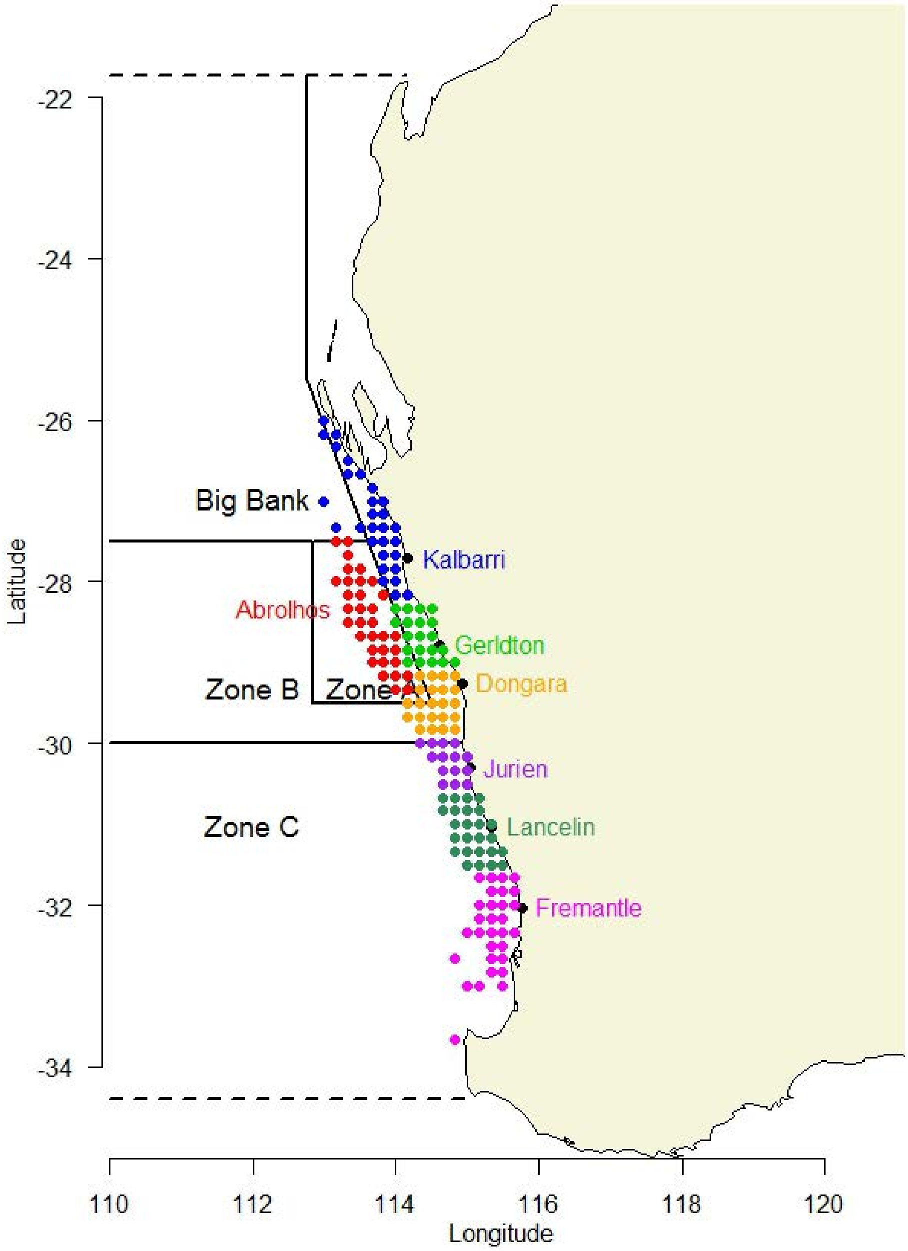

Figure 2.1 Location of monitoring ports throughout the Western Rock Lobster Managed Fishery and the corresponding commercial fishing blocks (dots) to which the non-retained monitoring data is ascribed.

The major retained species are outlined below according to the resource group they come from. All retained species comprise less than the 5% of landings of this fishery, with the dominant retained species (octopus) comprising only 0.2% of the landings of western rock lobster in 2015.

2.2 Results

As they are a statutory return, CDRs represent the most accurate measure of retained species number and weights (Table 2.1).

Table 2.1 Common name and weight (kg.), number (*n*) of species retained by commercial western rock lobster fishers from 2013 to 2015 catch disposal returns where the combined weight from the three seasons is greater than 15 kg.

Taxon	Common Name	2013 kg (*n*)	2014 kg (*n*)	2015 kg (*n*)
Cephalopods	Octopus	17450 (37651)	10666 (13510)	10282 (12480)
Cephalopods	Cuttlefish	52 (29)	72 (28)	271 (112)
Crustacean	Champagne Crab	2 (2)	382 (301)	1066 (850)
Crustacean	Slipper Cray	40 (52)	1 (1)	4 (5)
Crustacean	Crab	0 (0)	4 (16)	19 (16)
Elasmobranch	Wobbegong	51 (21)	454 (120)	242 (61)
Elasmobranch	Gummy Shark	2 (1)	118 (27)	0 (0)
Teleost	Baldchin Groper	188 (191)	1438 (627)	1542 (657)
Teleost	Pink Snapper	22 (10)	290 (130)	264 (101)
Teleost	Breaksea Cod	8 (5)	147 (134)	228 (241)
Teleost	Dhufish	0 (1)	106 (28)	72 (23)
Teleost	Red Throat Emperor	0 (0)	67 (29)	68 (30)
Teleost	Leatherjacket	0 (0)	4 (4)	26 (19)
Teleost	Parrotfish	20 (23)	1 (2)	0 (1)
Teleost	Fin Fish	0 (0)	4 (4)	15 (10)
Unknown	By Catch	3 (3)	31 (18)	102 (62)

Note: octopus is >0.2% of the 6 million kg WRL catch and all other species are at least an order of magnitude less, i.e. >0.02% of the WRL catch.

When bycatch species were recorded during on-board monitoring, estimated total numbers were greater than (ratio >1) the actual number of animals landed as recorded through statutory CDRs (Table 2.2). The only exception was pink snapper in 2015, where the number kept were underestimated by commercial monitoring. Octopus had comparatively accurate estimates from the two methods, with only a 1% difference between estimates in 2015.

Table 2.2 Number of species where the combined weight from the two seasons (2014 & 2015) is greater than 15 kg. Retained by commercial western rock lobster fishers from catch disposal returns (CDR), estimated number retained from commercial monitoring (Monitor) and the ratio of numbers from monitoring compared with CDRs

Taxon	Common Name	2014			2015		
		CDR	Monitor	Ratio	CDR	Monitor	Ratio
Cephalopods	Octopus	13510	17728	1.31	12480	12641	1.01
Cephalopods	Cuttlefish	28	0		112	493	4.4
Crustacean	Champagne Crab	301	0		850	3971	4.67
Crustacean	Crab	16	0		16	0	
Crustacean	Slipper Cray	1	0		5	0	
Elasmobranch	Wobbegong	120	0		61	80	1.31
Elasmobranch	Gummy Shark	27	0		0	0	1
Teleost	Baldchin Groper	627	1880	3	657	1679	2.56
Teleost	Breaksea Cod	134	724	5.4	241	850	3.53
Teleost	Pink Snapper	130	253	1.95	101	36	0.36
Teleost	Red Throat Emperor	29	0		30	0	
Teleost	Dhufish	28	0		23	0	
Teleost	Leatherjacket	4	0		19	0	
Teleost	Fin Fish	4	0		10	0	
Teleost	Parrotfish	2	0		1	0	
Unknown	By Catch	18	0		62	0	

Records from commercial monitoring show a number of fish species, sharks and some smaller crustaceans were returned, with the vast majority being returned alive. Only baldchin groper and damsel fish had individuals returned which were not alive (Table 2.3). Given the likely over-estimates of numbers from commercial monitoring compared to those from CDRs (Table 2.2), it is considered that the estimates of species being returned to the sea are an upper limit.

Table 2.3 Common names and estimated number of species retained, returned alive or returned dead from on-board commercial monitoring data.

		2014				2015			
Taxon	Common Name	Kept	Return Alive	Return Dead	Total	Kept	Return Alive	Return Dead	Total
Cephalopods	Octopus	17728	1107	0	18835	12641	0	0	12641
Cephalopods	Cuttlefish	0	0	0	0	493	0	0	493
Crustacean	Champagne Crab	0	0	0	0	3971	0	0	3971
Crustacean	Hermit Crab	0	422	0	422	0	497	0	497
Crustacean	Swell Crab	0	435	0	435	0	314	0	314
Elasmobranch	Wobbegong	0	286	0	286	80	2195	0	2275
Elasmobranch	Port Jackson	0	1183	0	1183	0	915	0	915
Elasmobranch	Tiger Shark	0	0	0	0	0	29	0	29
Teleost	Baldchin Groper	1880	1075	0	2955	1679	691	169	2539
Teleost	Breaksea Cod	724	1711	0	2435	850	1093	0	1943
Teleost	Western Wirrah	0	0	0	0	0	489	0	489
Teleost	Leopard Wirrah	0	250	0	250	0	412	0	412
Teleost	Eel	0	535	0	535	0	397	0	397
Teleost	Scorpion Cod	0	0	0	0	0	350	0	350
Teleost	Damsel Fish	0	507	0	507	0	87	169	256
Teleost	Leatherjacket	0	168	0	168	0	256	0	256
Teleost	King Wrasse	0	975	0	975	0	234	0	234
Teleost	Blacktipped Cod	0	258	0	258	147	52	0	199
Teleost	Footballer Sweep	0	37	0	37	0	147	0	147
Teleost	McCullochs Scalyfin	0	131	0	131	0	147	0	147
Teleost	Gurnard	0	0	0	0	0	144	0	144
Teleost	NW Blowfish	0	240	359	599	0	133	0	133
Teleost	Spangled Emperor	0	0	0	0	100	0	0	100
Teleost	Pink Snapper	253	274	0	527	36	57	0	93
Teleost	Orange Puffer	0	0	0	0	0	57	0	57
Teleost	Dhufish	0	549	0	549	0	0	0	0
Teleost	Banded Sweep	0	295	0	295	0	0	0	0
Teleost	Gold spotted Sweetlips	0	274	0	274	0	0	0	0
Teleost	Cod	0	161	0	161	0	0	0	0
Teleost	Chinaman Cod	31	84	0	115	0	0	0	0
Teleost	Foxfish	114	0	0	114	0	0	0	0
Teleost	Lined Dotty back	0	101	0	101	0	0	0	0
Teleost	Scorpion Fish	0	98	0	98	0	0	0	0
Teleost	Rankin Cod	0	42	0	42	0	0	0	0

2.3 Retained Species

Status reports for each the retained species described below can be found in the Status Reports of the Fisheries and Aquatic Resources of Western Australia. The most recent report, 2014/15, can be found at: http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2014-15.pdf

2.3.1 Rock Lobster

The catch, effort and catch rates of western rock lobster are detailed in de Lestang et al. (in press). Prior to the move to an output management system in 2009/10, catches were strongly influenced by the puerulus settlement three to four years prior. However, with the introduction of quota management, catches were significantly reduced and have remained relatively stable. There has been a considerable reduction in the level of effort required to attain the quota (Figure 2.2) compared to the effort expended under input control regime (pre 2009/10). Unsurprisingly, the catch rates in all zones of the fishery have increased dramatically since the move to a conservative quota management regime (Figure 2.3). Zone A continues to have a higher catch rate than the other two coastal zones, though all zones have seen three to four-fold increase in their standardized catch rate (standardized for high grading, timing and location of capture).

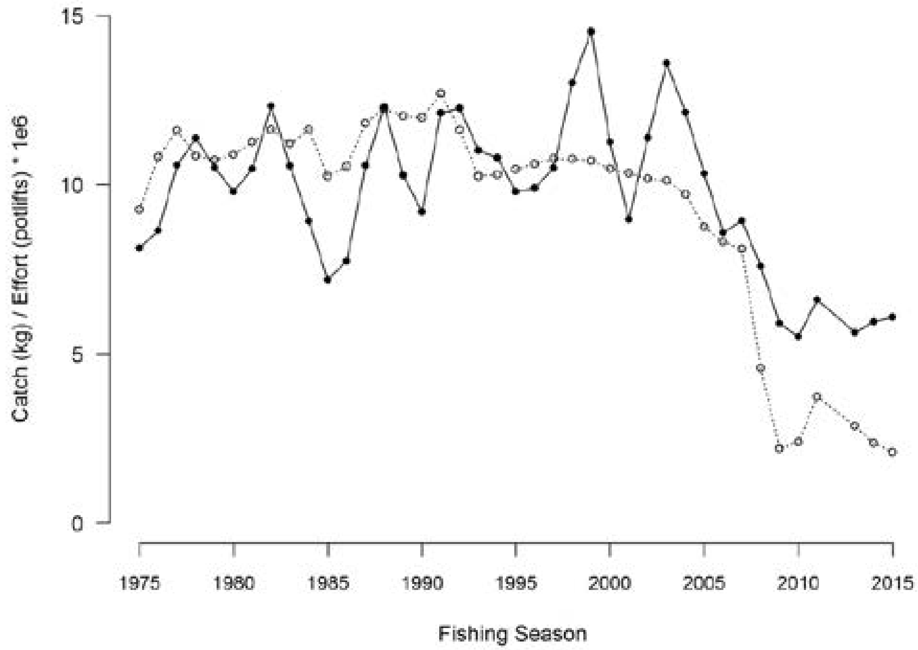

Figure 2.2 Catch (filled circles) and effort (open circles) of western rock lobster by season

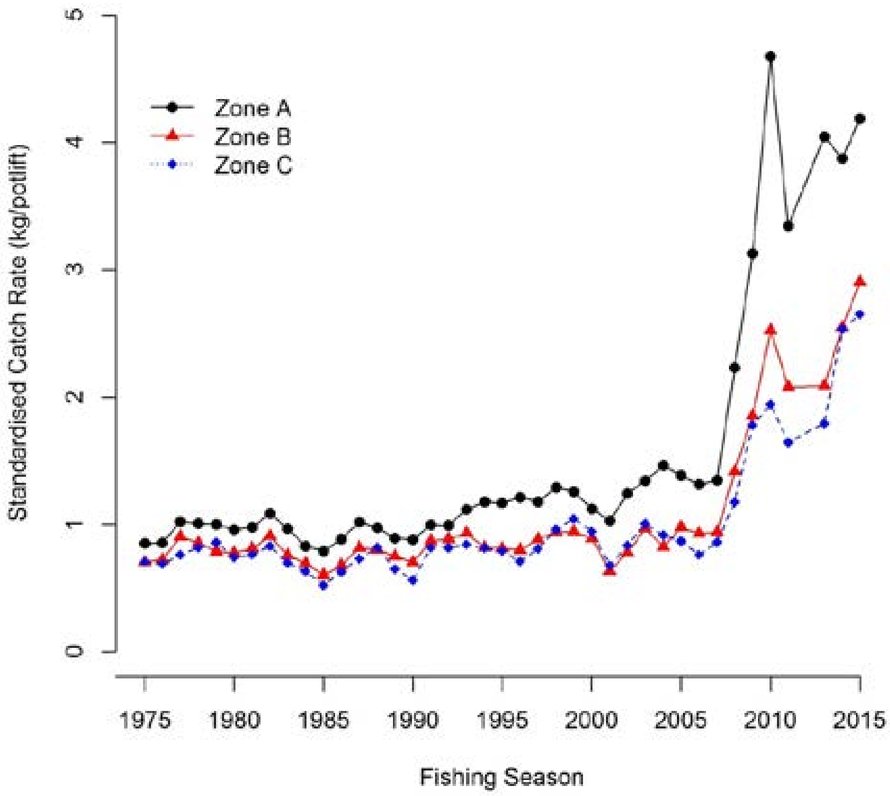

Figure 2.3 Standardized catch rates of western rock lobster by season and zone

In the 2015 season, 3 kg of southern rock lobster (*Jasus edwardsii*) was also caught. Catches of southern rock lobster are rare in the WRL as their distribution is usually restricted to the south coast of the state.

2.3.2 Cephalopods

Octopus is the dominant cephalopod captured by the Western Rock Lobster Fishery, is generally caught in rock lobster pots in shallow water (< 40 m) and is retained by fishers and sold as bait for recreational finfish fishing. Octopus landings increased from generally less than a tonne prior to 1989, through to a peak of 169 tonnes in 2009. Catches have since declined due to reduced fishing effort, with 10.2 tonnes being landed in 2015 (Figure 2.4a). Since 1989, catch rates have remained relatively stable at between 0.005 and 0.015 kg per potlift (Figure 2.4b). Landings of octopus in 2015 from CDR data was 10,282 kg, with all of them being retained (Table 2.3).

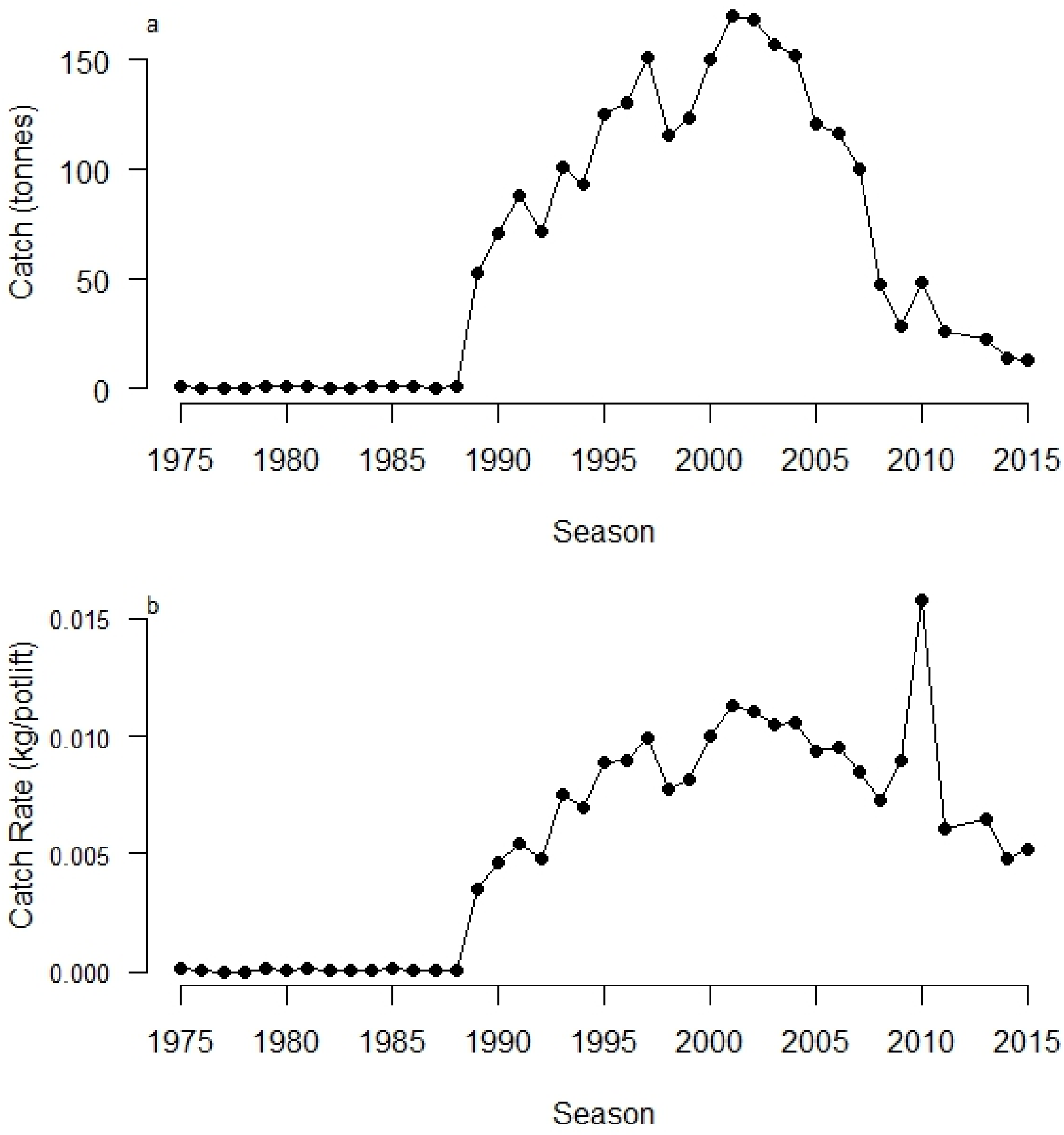

Figure 2.4 a) Catch and b) catch rate of octopus landed in the West Coast Rock Lobster Managed Fishery by season.

The octopus resource is managed under the Octopus Interim Managed Fishery Management Plan 2015.[3]

In 2015 270.9 kg of cuttlefish were retained which is an increase from the 51.5 and 75.5 kg recorded in 2013 and 2014 respectively. Commercial monitoring showed all cuttlefish being retained (Table 2.3).

2.3.3 Crustaceans

Deep sea crabs are captured as by-product when fishing in deep water (>100 m) for migrating

[3]The interim management plan for the west coast octopus fishery can be found at: https://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/6AE499EDCC6D43C848257EEB002F0018/$file/47.0+octopus+interim+mfmp+2015+-+27.10.15.pdf

white lobsters. The champagne crab *Hypothalasia armartus* can be retained by commercial fishers and sold. In 2015, 1,065.9 kg of champagne crab was retained, which is an increase from the 2.5kg and 381.5kg retained in 2013 and 2014 respectively (Table 2.1), with all being retained (Table 2.3). This increase in catch is expected given the increase in the deep water effort for rock lobster that has occurred during the 'whites' migration in 2014 and 2015 (de Lestang et. al in press). As previously mentioned WRL fishers can only retain 12 deep sea crabs per day.

H. armartus is also a retained species of the West Coast Deep Sea Crustacean Managed Fishery,[4] whose stock was recently certified as being sustainable by MSC (see the MSC certification report at: https://www.msc.org/track-a-fishery/fisheries-in-the-program/certified/indian-ocean/australian-west-coast-deep-sea-crab).

The only other species of crustacean recorded in any quantity is slipper crayfish (Scyllaridae). In 2013, 39.5 kg were retained, though quantities have decline in recent seasons with only 0.9 and 3.5 kg being retained in 2014 and 2015 respectively (Table 2.1).

In addition, a further 19 kg of unidentified 'crabs' were also recorded as retained by commercial rock lobster fishers in 2015(Table 2.1).

2.3.4 Scalefish

As fishing for WRL occurs throughout the mid-and lower west coast of Western Australia (Figure 1.1) there is a considerable overlap with species captured as part of the West Coast Demersal Scalefish Resource. These species do enter WRL pots, attracted by the bait, and may be captured when the pot is hauled, though the numbers are very small. No fishing gear (e.g. hooks/lines) are permitted on-board commercial WRL vessels and there is no targeting of these species. Fishers are permitted to retain scalefish for personal consumption only if they are captured in a pot and they must adhere to all recreational fishing regulations (e.g. size and bag limits; for full details see: http://www.fish.wa.gov.au/Documents/recreational_fishing/rec_fishing_guide/rules_guide_statewide.pdf).

The dominant finfish species retained by commercial WRL fishers, as recorded on their CDRs, are baldchin groper (*Choerodon rubescens*), and small number of breaksea cod (*Epinephiledis armatus*) and pink snapper (*Chrysophyrs auratus*) (Table 2.1). Two of these three species (baldchin grouper and pink snapper) are considered indicators for the West Coast Demersal Scalefish Resource which is currently assessed as recovering.[5] For the most

[4]The deep sea crustacean management plan can be found at: https://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/A531C79F8279DE6F48257E9E00242DC7/$file/44.1+west+coast+deep+sea+crustacean+fishery+mp+11.08.15.pdf

[5] See the west coast demersal scalefish management plan at: https://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/CE35B4889B1C5D0148257E9E00236105/$file/39.15+wes

recent assessment (2014/15) of the demersal scalefish resource for the West Coast and Gascoyne Coast Bioregions see pages 84 to 95 and 134 to 141 respectively of the Status Reports of the Fisheries and Aquatic Resources of Western Australia 2014/15 at: http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2014-15.pdf.

Baldchin groper and breaksea cod were also the two most common scalefish species recorded by on-board commercial monitoring (Table 2.3). The majority of species from this resource were retained. Those that were discarded (presumably because they were below the recreational minimum size) were returned to the water alive.

A further 15kg of unidentified fin fish was also retained by commercial fishers.

2.3.5 Elasmobranchs

Wobbegong (carpet sharks), as with scalefish, enter pots attracted by the bait, though numbers are low. These are often discarded (Table 2.3), however in 2015, 241.5 kg were retained, with commercial monitoring estimates of 80 wobbegongs retained. This catch is a decline from the 453.5 kg recorded in 2014, which contrasts with the 51 kg recorded in 2013 (Table 2.1).

The only other elasmobranch retained in any quantity was gummy sharks. There was no catch recorded in 2015, with only 2 kg in 2013 and 117.5 kg in 2014 (Table 2.1). About 1000 Port Jackson sharks were caught annually (2014 & 2015) and all were returned to the water alive (Table 2.3).

2.3.6 Shark finning

It is most unlikely that shark finning takes place in the WRLF, as the number of sharks caught in pots is low and the most common species taken (Wobbegong and Port Jackson sharks) are not considered suitable for finning. No evidence of shark finning by commercial WRL fishers was reported by compliance officers between 2010/11 and 2015/16 (Table 2.4). Regulation 16b of the FRMR deals with shark finning.[6]

t+coast+demersal+scalefish+-+11.08.15.pdf , associated Integrated Fisheries Management reports for west coast demersal fish under the West Coast heading at: http://www.fish.wa.gov.au/About-Us/Publications/Pages/Integrated-Fisheries-Management.aspx and a report on the Status of demersal finfish stocks on the west coast of Australia at: http://www.fish.wa.gov.au/Documents/research_reports/frr253.pdf .

[6] Regulation 16b of the FRMR can be found at: https://www.slp.wa.gov.au/pco/prod/FileStore.nsf/Documents/MRDocument:28503P/$FILE/Fish%20Resources%20Management%20Regulations%201995%20-%20[13-h0-00].pdf?OpenElement

Table 2.4 Annual number of compliance contacts.

Season	Compliance Contacts*
10/11	2219
11/13	1251
13/14	1167
14/15	970
15/16	803

*Does not include some at sea gear inspections conducted by the Department's large patrol vessels.

2.4 Bycatch

There were a suite of species which were discarded (Table 2.3). This could be for a variety of reasons e.g. under the legal size or they not considered edible such as NW Blowfish. Estimated numbers of captured species are low and are likely to be an overestimate given current comparisons between commercial monitoring and statutory CDR figures (Table 2.2).

3 Bait

WRL are captured using baited pots. Pots are set with the bait used as an attractant to the pot. Preference for bait types has changed over the last 10 years. Blue Mackerel (*Scomber australasicus*) has remained the preferred bait type, while Hoki (*Macruronus novaezelandiae*) and Orange Roughy (*Hoplostethus atlanticus*) have increased in popularity while useage of Australian Salmon (*Arripis trutta & A. truttaceus*) and North Sea Herring (*Claupea harengus*) have decreased (Figure 3.1).

There has been a decline in the amount of bait used in the fishery (Figure 3.2). Bait used in the current season (2015) is less than a quarter of that used ten years ago. Under quota management, the bait used to capture a kilogram of lobster has fallen to around 0.5 kg of bait. This is approximately half of what was required to capture a kilogram of lobster prior to 2009/10 when the fishery was under input (effort) controls. However, the kilograms of bait per pot lift, shows a different pattern (Figure 3.3). From 2000/01 to 2007/08 rates were steady at around 1.5 kg per potlift, followed by an increase in 2008/09 and 2009/10 seasons, with over 2 kg of bait per potlift being used in 2009/10. This coincided with a season where there was an industry-wide competitive quota and bait usage would have increased in an attempt to "out compete" other fishers. Since the transition to individual transferable quota (ITQ) in 2010/11 there has been a dramatic decline in bait usage to around 1 kg per pot lift, but since 2010 it has steadily increased to pre-quota levels of around 1.5 kg per pot lift in 2015 (Figure 3.3).

In accordance with the Department's draft Bait Management Policy, a number of bait species are considered out of scope for MSC assessments. These include (i) bait of terrestrial origin such as kangaroo meat or pig fat, (ii) by-products of fishery/aquaculture activities such as heads or frames; and (iii) feral aquatic species harvested as part of an eradication program.

The majority of bait (~70%) used by the West Coast Rock Lobster Fishery is outside the scope for MSC assessment. Of the species that are in scope, blue mackerel (*Scomber australasicus*) is the major bait species and is sourced from a managed fishery in New Zealand (http://fs.fish.govt.nz/Page.aspx?pk=113&dk=23811). Blue mackerel was assessed as being 'likely' to be above the 'soft limit' according to an assessment conducted in 2006 (http://fs.fish.govt.nz/Doc/24003/Stock%20Status%20Table%20Nov%202015%20symbols.pdf.ashx). Australian herring and salmon are sourced from Western Australia and are both part of the South Coast Nearshore and Estuarine Finfish Resources, with Australian herring also being part of the West Coast Nearshore and Estuarine Finfish Resources.[7] Australian salmon[8]

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[7] See https://www.slp.wa.gov.au/statutes/subsiduary.nsf/FisheriesT?OpenPage&Start=1 for management plans relating to west and south coast estuary fisheries and other near shore fisheries.
[8] See the salmon management notice at: https://www.slp.wa.gov.au/statutes/subsiduary.nsf/0/BD258F2B15A311DD48256E3C000DD3CD/$file/03a+south+coast+salmon+28-12-01.pdf and the latest salmon resource assessment report in the State of the Fisheries report 2014-15, South Coast Bioregion, pages 247 to 258 at: http://www.fish.wa.gov.au/About-

has been assessed as adequate, while the Australian herring was assessed as inadequate in both the south and west coasts.[9] Since early 2015 the West Australian herring fishery has been managed under a recovery 'plan', the core of which was to reduce the total catch of herring by 50%. To this end the commercial herring haul and "G" net fisheries (the major source of the commercial herring catch) were closed and the recreational daily bag limit was reduced from 30 to 12. Ministerial and Department announcements regarding the management changes to the herring fishery can be found at: http://www.fish.wa.gov.au/About-Us/Media-releases/Pages/_archive/Getting-the-balance-right-for-Herring-recovery.aspx, http://www.fish.wa.gov.au/Species/Australian-Herring/herring-management/Pages/Herring-Management.aspx & http://www.fish.wa.gov.au/Documents/recreational_fishing/additional_fishing_information/rebuilding_the_herring_stock.pdf). Links to herring status reports and external reviews of status reports, along with a biological synopsis of Australian herring and a Department recreational pamphlet are provided in the footnote below.[10] Now, only small quantities of herring are caught in the in WA for human consumption.

Details on the amount and type of bait used for the current season (2015) is presented in Table 3.1.

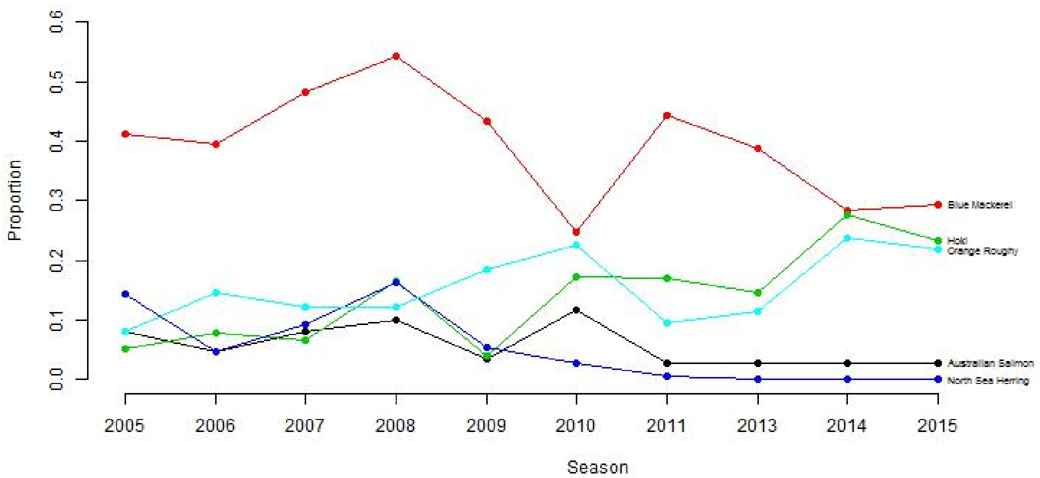

Figure 3.1 Proportion of bait types used by season whose average since 2005 was greater than 5% of bait used.

Us/Publications/Pages/State-of-the-Fisheries-report.aspx
[9] For the most recent published assessment of the WA herring stocks see: http://www.fish.wa.gov.au/Documents/sofar/status_reports_of_the_fisheries_and_aquatic_resources_2014-15.pdf pages 247 to 258.
[10]Status report on Australian herring and tailor: http://www.fish.wa.gov.au/Documents/research_reports/frr247.pdf , A review of the status report on Australian herring and tailor: http://www.fish.wa.gov.au/Documents/occasional_publications/fop116.pdf , a biological synopsis of Australian herring: http://www.fish.wa.gov.au/Documents/research_reports/frr251.pdf and the herring fact sheet: http://www.fish.wa.gov.au/Documents/recreational_fishing/fact_sheets/fact_sheet_australian_herring.pdf

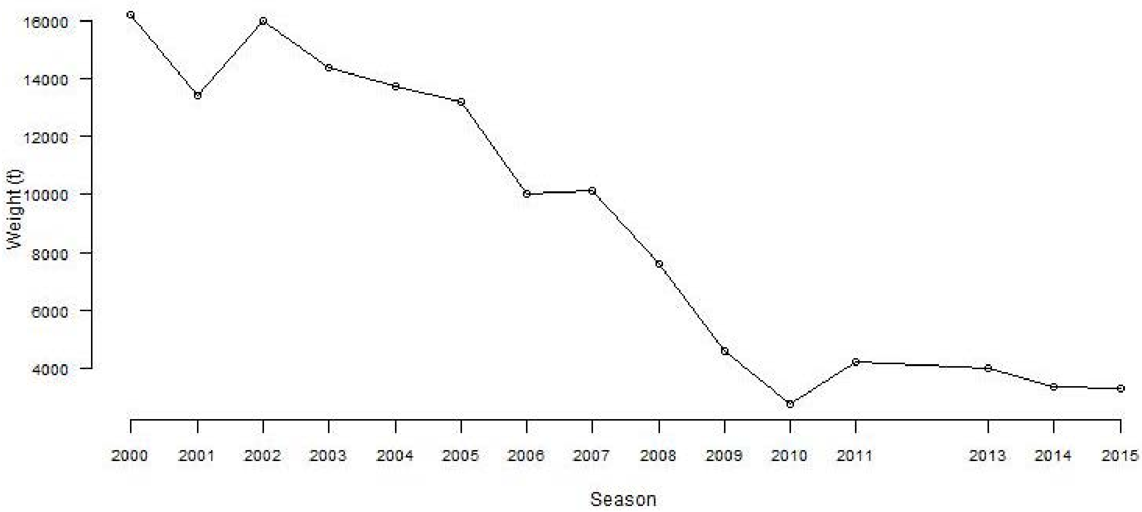

Figure 3.2 Total bait used (tonnes) per season in the West Coast Rock Lobster Managed Fishery. Note the 2011 season was an extended season and encompassed all of 2012 (see de Lestang et al. in press for more details).

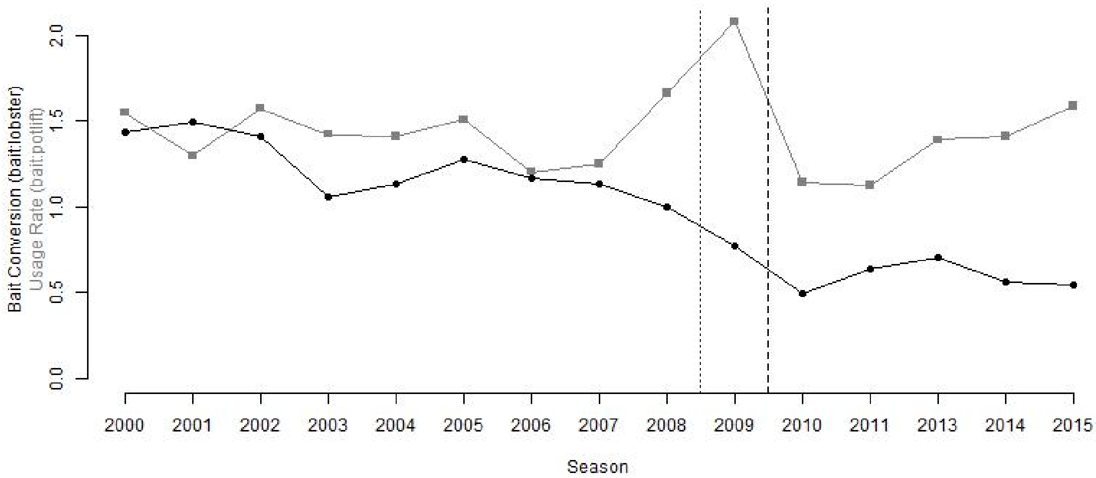

Figure 3.3 Bait to lobster conversion ratio (kg of bait to kg of lobster) and usage rate (kg bait per potlift) of all bait for the Western Coast Rock Lobster Managed Fishery. Dotted line indicates the period before which the fishery was effort control, and after the dashed line was an ITQ quota managed fishery. The season between the two lines was a season with an industry-wide (competitive) quota.

Table 3.1 Amount of bait used in the West Coast Rock Lobster Managed Fishery for the 2015 season by species, origin, type and its status with regard to MSC assessment.

Bait	Origin	Type	Amount	Status	% WRL Catch
Blue Mackerel	New Zealand	Whole	842210	in scope	14.04
Australian Herring	Western Australia	Whole	66078	in scope	1.1
Australian Salmon	Western Australia	Cutlets	38538	in scope	0.64
Sardines	New Zealand	Whole	40	in scope	0
Hoki	New Zealand	Heads	776167	out of scope	12.94
Orange Roughy	New Zealand	Heads	720539	out of scope	12.01
Alfonsino	New Zealand	Heads	153338	out of scope	2.56
Blue Mackerel	New Zealand	Heads	125280	out of scope	2.09
Kahawai	New Zealand	Heads	106745	out of scope	1.78
Pork Fat	Western Australia		78350	out of scope	1.31
Pork Fat	South Australia		64050	out of scope	1.07
Alfonsino	Victoria	Heads	57494	out of scope	0.96
Tuna	Thailand	Heads	55600	out of scope	0.93
Australian Salmon	Western Australia	Heads	51389	out of scope	0.86
Mackerel	Taiwan	Heads	39360	out of scope	0.66
Pork Fat	New Zealand		37800	out of scope	0.63
Spanish Mackerel	New Zealand	Heads	27800	out of scope	0.46
Jack Mackerel	New Zealand	Heads	10440	out of scope	0.17
Blue Mackerel	Korea	Heads	6980	out of scope	0.12
Barracouta	New Zealand	Heads	2452	out of scope	0.04
Kangaroo	Western Australia	Whole	1220	out of scope	0.02
Goldfish	New Zealand	Heads	525	out of scope	0.01
Gem Fish	New Zealand	Heads	100	out of scope	0

4 Endangered, threatened and protected species

It is a statutory requirement that all interactions between the WCRLF and endangered, threatened and protected (ETP) species are recorded on a Catch and Disposal Record (CDRs) which is completed for each commercial fishing trip. During the 2015 season (15th January 2015 – 14th January 2016) commercial fishers recorded five interactions with ETP on their CDRs. These 'interactions' were with whales, with comments associated with the report stating that they 'observed whales'. As these reports were clearly not physical interactions with ETPs, no interactions with ETPs were reported during the 2015 season on CDRs.

Due to the nature of interactions with some protected species, such as whales, it is unlikely that fishers would actually observe the interaction with their gear. There are additional reporting systems which can provide information on ETP interactions which are administered by the Department of Parks and Wildlife (WA). These records noted two entanglements of humpback whales with WCRLF gear in 2015.

4.1 Sea lions and SLEDS

Interactions between the WCRLF and the Australian sea lion (*Neophoca cinerea*) have resulted in the accidental drowning of a small number of sea lion pups in WRL pots, as the pups attempted to retrieve bait or WRL from the pots (de Lestang *et al*. 2010b). Incidents were restricted to shallow waters (< 20 m) and to areas within 30 km of the mainland sea lion breeding colonies along the mid-west coast. Sea lion interaction with pots was therefore identified as a moderate risk in the initial 2001 ERA (IRC Environment 2009). A sea lion scientific reference group (SL SRG) was formed and research conducted into possible mitigation of the risk.

Interactions between sea lion pups and lobster pots have also been recorded at the Abrolhos Islands (Brown and How 2011). Previous research had not detected any interactions; however, during the 2007/08 season a dead sea lion pup, which a post-mortem revealed had drowned, was found on the Department of Fisheries jetty. Although the reason for the mortality was inconclusive, research has shown that sea lion pups do interact with WRL pots at the Abrolhos Islands. Given the small size of the sea lion population in the area, even a small additional mortality due to interactions with WRL pots (1-3 pups per 12-18 months) could severely compromise the viability of the population.

4.1.1 Management Action

In order to eliminate further drowning of sea lions, a sea lion exclusion device (SLED) was developed as part of Fisheries Research and Development Corporation (FRDC) funded project with video trials demonstrating that this device does stop sea lion pups from entering WRL pots and drowning. Approved SLED designs were mandated to include an internal rigid structure, directly under the pot neck and an external design across the top of the pot (Figure

4.1). Both internal and external structures ensure that the diagonal distance from the SLED to the neck of the pot is not greater than 132 mm.

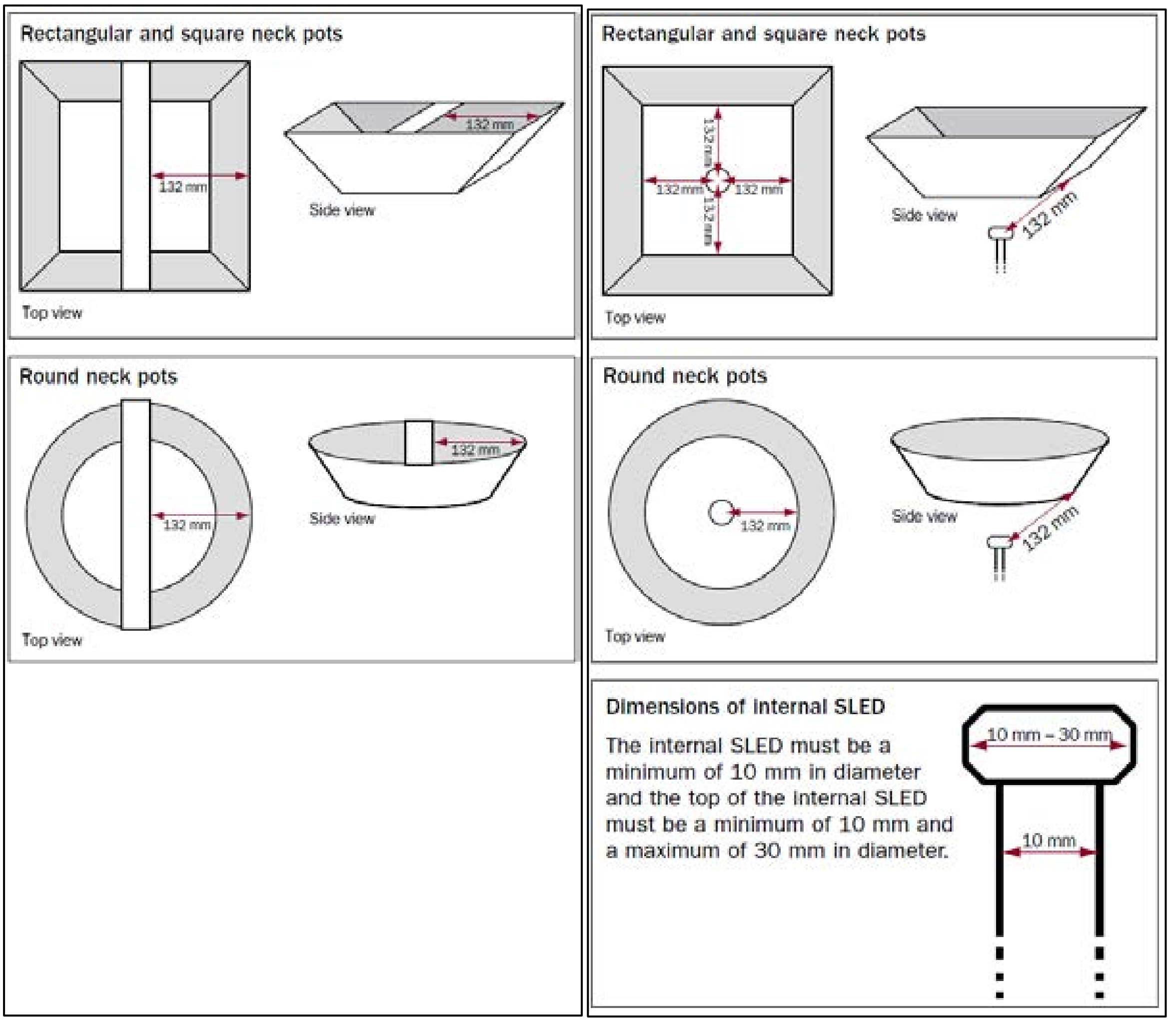

Figure 4.1 Diagrammatic representation of the regulations required for installing sea lion exclusion devices (SLEDs) to (left) the top of a pot and (right) the inside of a pot

Mandatory introduction of SLEDs to areas of “potential sea lion interaction” occurred in November 2006 on the state’s central coast (Figure 4.2). All pots in waters less than 20 m within approximately 30 km of the three breeding colonies, i.e. just north of Freshwater Point to just south of Wedge Island, were fitted with approved SLEDs.

The discovery of the dead sea lion pup at the Abrolhos Islands, and the vulnerability of these populations saw the same SLED design used on the mainland being implemented in SLED areas at the Abrolhos Islands. Risk areas for interactions at the Abrolhos Islands were identified as being in waters of 0-20 m depth around the Easter and Pelsaert (Southern) Groups, which are areas of sea lion pup distribution and frequent foraging by both juvenile and female sea lions (Figure 4.2). Voluntary implementation of SLEDs occurred in these risk areas for the 2010 Zone A season (15 March – 30 June), with SLEDs mandatory in the risk areas for the 2011 season.

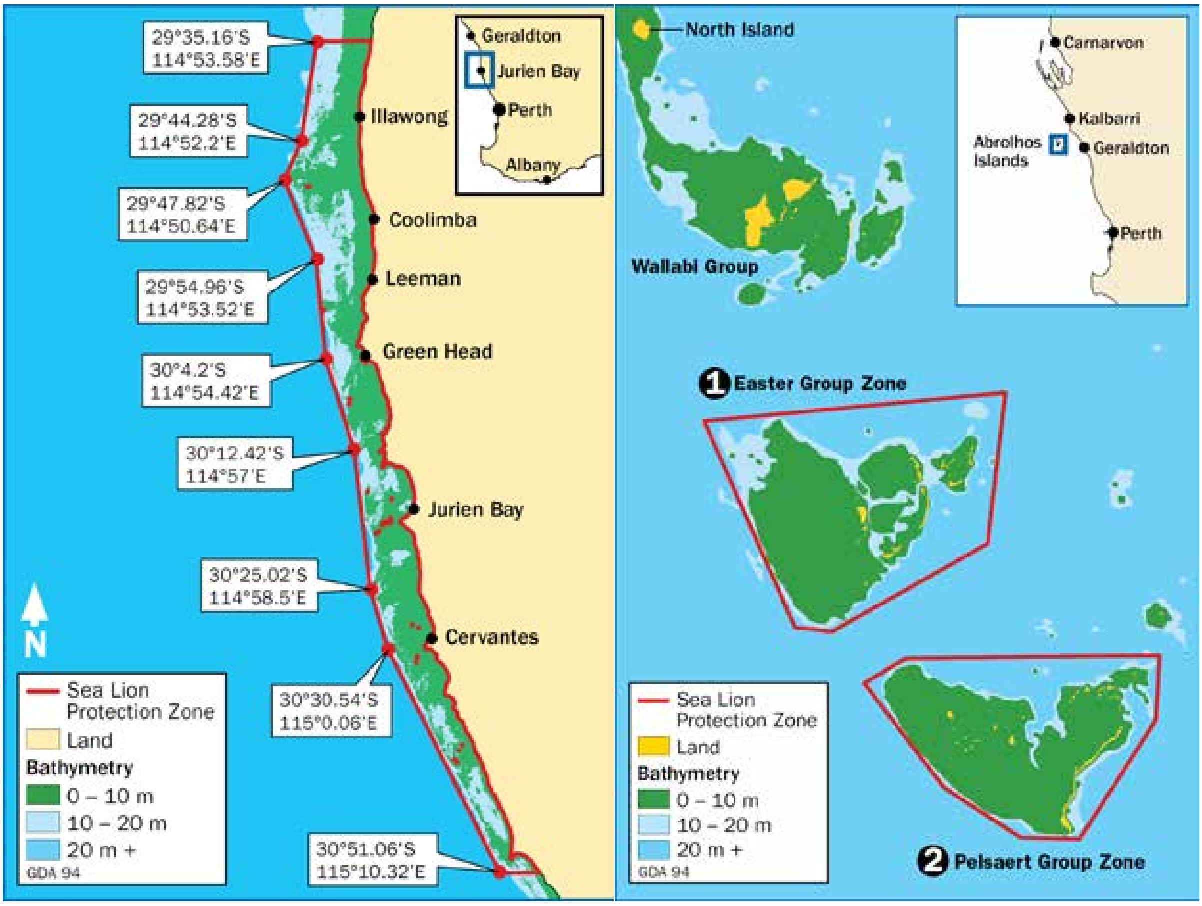

Figure 4.2 Maps illustrating the locations of the two sea lion exclusion device zones (left) for the central west coast and (right) the Abrolhos Islands

These regulations apply to both commercial and recreational fishers operating within the SLED zones. Further information about the SLED management package is available at http://www.fish.wa.gov.au/docs/pub/SeaLionExclusionDevices/index.php.

4.1.2 Information and Monitoring

Compliance checks are undertaken on the adherence of fishers to SLED regulations. Inspection of commercial WRL pots in the SLED zone in 2007/08 and 2008/09 showed that over 95 % of pots checked had an approved SLED. After the introduction of SLEDs into the central west coast area during the 2006/07 seasons, the risk of sea lion interactions with pots was reduced from moderate to low in the 2007 ERA (Stoklosa 2007).

In 2015, there were 125 checks of gear for SLED compliance. This resulted in three warnings of commercial fishers, 11 infringements of recreational fishers and 11 warnings of recreational fishers being issued.

4.2 Cetaceans

The population of humpback whales (*Megaptera novaeangliae*; Breeding Stock 'D') migrates along the west coast of Australia and is the largest population of humpback whales in the southern hemisphere (Leaper *et al.* 2008). The current population size is above 30,000 (Branch 2011) and estimated to continue increase and is approaching pre-whaling levels (Bejder et al. 2016). The population migrates north along the coast starting around the south west corner of the state (34^{o}S) in June, continuing north through until August. By the end of August (Jenner et al. 2001) the majority of whales surveyed off Ningaloo (22^{o}S) were undertaking their southern migration (Chittleborough 1953) which extends through to November.

Under previous effort controls, the season for WRL fishing operated between mid-November and the end of June which resulted in between zero and four entanglements annually. This level (0-4 entanglements) was set as a performance indicator for the fishery, although it was recognised that the rate of whale interactions was likely to increase through time given the increased numbers of whales migrating along the west coast. However, in recent seasons there has been an increase in the number of reported whale entanglements with commercial fishing gear, and WCRLF gear in particular (Figure 4.3). The increase in whale entanglements was a result of increased fishing effort during the winter months, with the increase in entanglements coinciding with changes in the management of the WCRLF.

In November 2010 (2010/11 season) there was a significant change to the management arrangements for the WCRLF, moving to an output-based quota fishery. The move to quota-based management has included the season extending until the end of August in 2011 and September in 2012. The 2013/14 season was the first season with no temporal closure, allowing fishing to occur year round.

To reduce whale entanglements, and address conditions placed on the fishery by the federal government two Fisheries Research and Development Corporation (FRDC) projects were funded. They focused on providing information on appropriate gear modifications and spatial and temporal information on whale migration patterns such that this information could be incorporated in to management measure to reduce whale entanglements.

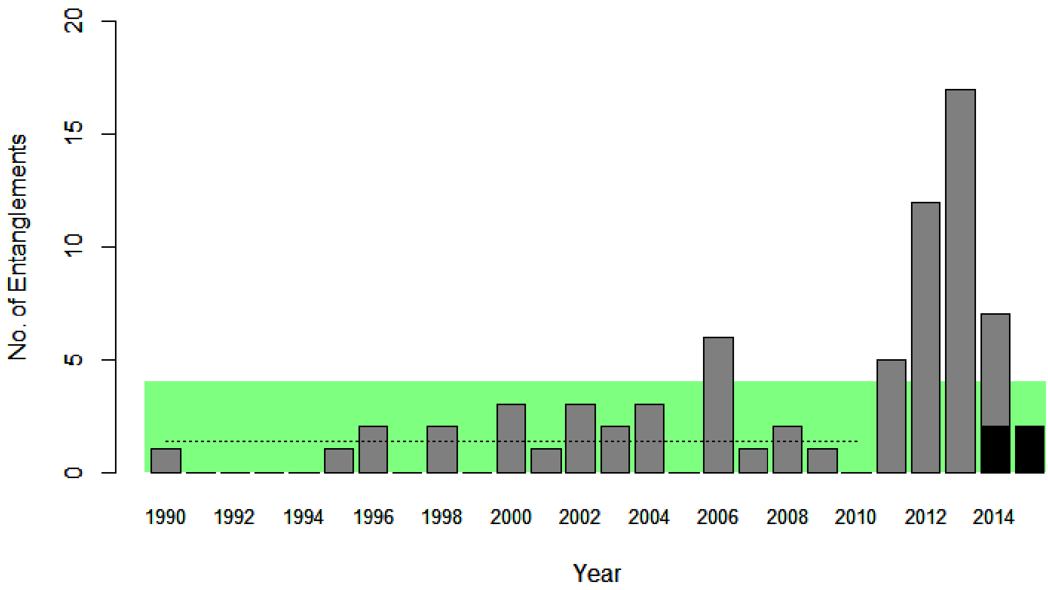

Figure 4.3 Annual number of entanglements of whales in western rock lobster gear when gear modifications were not (grey) or were (black) required. Target area of performance measure (green) Gear modifications were introduced in June 2014, midway through the migration season

4.2.1 Management Action

To mitigate the number of entanglements with migrating whales, legislated gear modifications were implemented on 1 July 2014. They were based around a reduction in rope use, elimination of slack line on the surface as well as a reduction in the number of floats used (Table 4.1; How *et al.* 2015). These gear modifications were only required in waters generally deeper than 20 m. Since their introduction, there have been a few minor amendments to the original modification to permit ease of compliance and fishing (Table 4.2); however the intent of the modifications remained constant.

Table 4.1 Gear modification requirements for maximum rope length, surface rope, floats and float rig length and periods between pulling pots for both shallow and deep water. * Shallow water was defined by the depth that could be fished with the maximum unweighted rope component (see Table 4.2)

	Shallow Water * (~< 20 m)	Deeper Water (> 20 m)
Rope length	No rope / water depth ratio	Rope (bridle-float) < 2x water depth
Surface rope	Surface rope permitted	No surface rope [negatively buoyant rope (top third)]
Float rig	Float rig inc. in total rope	Max float rig 5 fathoms (inc. tail)
Floats	Max. 2 floats	Max. 2 floats (<30 fathoms) Max. 3 floats (>30 fathoms)
Pull Period	No max pull period	Pots pulled once every 7 days

Table 4.2 Changes to the maximum unweighted rope and season timings by season since the gear modifications were introduced.

Season	Maximum Unweighted Rope	Whale mitigation season
2014	15 fathoms	1 Jul – 14 November
2015	18 fathoms (inside whale zone[1])	1 May – 14 November
2016	18 fathoms	1 May – 31 October

[1] The ‘whale zone’ was a defined region within the fishery that generally encompassed waters less than 20 m

4.2.2 Information and Monitoring

Compliance checks are undertaken on fishers' adherence to whale gear mitigation regulations. In 2015 there were 456 checks of gear for whale gear modification compliance. This resulted in nine warnings of commercial fishers and three infringements of commercial fishers being issued. As gear modifications were introduced during the 2014 migration season, the compliance statistics from 2015 represent the first full year of compliance data relating to whale entanglements gear modifications.

An assessment of the effectiveness of gear modifications in reducing entanglements has been undertaken. This assessment incorporated expected changes in whale population size, reporting rate, commercial fishing effort and the implementation of gear modifications (started in July 2014). The analyses indicate gear modifications reduced entanglements by around 60%. The model also highlighted the northern part of the migration and water depths of 36.6 - 54.8 m (20-29 fathoms) as the times and areas most associated with entanglements (For full details of the assessment see How *et al*. (in prep)).

4.3 Dusky Whalers (*Carcharhinus obscurus*)

The 2007 ERA (Stoklosa 2007) used an Ecological Risk Assessment for Effects of Fishing (ERAEF) methodology to assess potential ecological risks posed by the WRL fishery and identified dusky whaler sharks mortality caused by bait bands as a moderate risks: This was the only one of four moderate risks which were able to be subjected to the Level 2 Productivity-Susceptibility Analysis' (PSA).

The analysis revealed that *C. obscurus* was a low productivity species; making bait bands a threat to the stock as they lack resilience to by catch mortality (Stoklosa 2007).

4.3.1 Management Action

A state-wide ban on plastic bait bands on board all fishing boats operating in WA waters was implemented on 15 November 2011. At the 2013 ERA the risk of bait bands to dusky whalers was re-assessed. Due to the state-wide ban in place it was considered that the risk of dusky whaler sharks becoming entangled in discarded plastic bands due to the WCRLF (or any other commercial fishery in WA) was negligible. It was recommended that in the short term no further assessment of bait band entrapment hazards to dusky was required (see ERA for further details http://www.fish.wa.gov.au/Documents/occasional_publications/fop118.pdf).

4.3.2 Information and Monitoring

Compliance checks are undertaken on the adherence of fishers to bait band regulations. In 2015 there were 715 vessels checked for bait band compliance. This resulted in eight infringements of commercial fishers and one warning of a commercial fisher being issued.

4.4 Turtles

Interaction between turtles and the WCRLF by entanglement with WRL pot ropes or boat strikes, was identified as a moderate risk in the 2001 ERA (IRC Environment 2009). Information presented at the 2005 ERA (Burgman 2005) from voluntary surveys of WRL fishers from 1999/2000 - 2001/02 seasons highlighted 34 interactions, with five mortalities over the three seasons (Table 4.1).

Table 4.3 Interactions and mortalities of sea turtles from three years of annual bycatch surveys (Burgman 2005).

Season	Interactions	Mortalities
1999/2000	12	1
2000/2001	17	3
2001/2002	5	1

The assessment of the expert groups, while considering the consequence of further impacts as severe or major, decided that given the decline in sea turtle populations the likelihood of extra mortalities associated with the fishery was very unlikely. This resulted in a reclassification of this risk as low.

Turtle deaths as a direct result of interaction with the WCRLF are rare. Of the six turtle species that occur in the waters of the WCRLF, only the entanglement of leatherback turtles (*Dermochelys coriacea*) was concluded to be above a negligible risk, and this was still rated as a low risk. Given the significant reductions in fishing effort and pot ropes in the water, the current risk is now likely to be even lower (de Lestang et al. 2010b).

4.4.1 Management Action

There has been no specific management strategy developed for turtles given the risk as assessed as low (Burgman 2005, Stoklosa 2007, Stoklosa 2013). However, the major interaction of turtles with the WRLMF is through entanglements. The gear modifications introduced to reduce whale entanglements (see 4.2 Cetaceans) will also reduce the entanglement of turtles, as slack line in the water was likely to be a major cause of entanglement with previous gear configurations.

4.4.2 Information and Monitoring

The performance measure for the fishery is that there is no increase in interactions with turtles. The historical range of turtle entanglements is between two and five entanglements per season. In 2015 there were no reported entanglements of turtles in WCRLMF gear.

5 Understanding Habitat Structure

A substantial portion of the benthic habitats within the WCRLF have been mapped to describe both the physical substratum and the biological communities. This mapping is largely a result of different government and private agencies undertaking habitat mapping in relation to coastal development projects and marine reserve planning. The information available spans several decades and has been collected using different methods (due to technological advances) and spatial scales. Despite these inconsistencies, habitat classification categories are similar across the regions, providing a comprehensive overview of benthic habitats associated with WRL.

A detailed summary of historical benthic habitat information for the extent of the WCRLF can be found in Bellchambers *et al* 2012 with relevant historic research listed in Table 5.3 of this document. The remainder of this section will outline the habitats used by the WRL and ongoing broad-scale habitat mapping the Department of Fisheries WA undertakes over the extent of the WCRLF.

5.1 Habitats used by the western rock lobster

Habitats used by the WRL, and their population structure within these habitats, are largely confined to the limestone reef systems fringing the central coast of Western Australia, reef systems surrounding offshore islands (e.g. Houtman Abrolhos Islands), and offshore reef systems in deeper waters (e.g. Big Bank). However, WRL can be found across the continental shelf where they use a range of habitats at different stages of their life cycle:

- Phyllosoma spend up to 12 months in the water column before settling as puerulus onto seagrass and algal meadows found within nearshore habitats. Post-puerulus (< 25 mm carapace length, 1+ year) usually inhabit small holes in the reef and reef face along algal or seagrass communities, which are used as shelter and a food resource. As the WRL grow, they move into larger spaces where they begin to share the den habitat of juvenile lobsters in caves and ledges (Fitzpatrick *et al*. 1990).
- Juveniles forage and grow among reef habitats until they become sub-adults. Habitat surveys near Geraldton revealed high densities of sub-adult WRL among high reef areas and low reef areas at Point Moore, and the low reef and high reef blocks at Georgia (Monaghan Rooke and Robinson 1993, 1994) (Figure 5.1). Shelter (caves, crevices and ledges) is most abundant in the dissected pavement habitat that occurs at about 4-6 m depth and is limited on the featureless rock pavement. Other habitats such as sand and limestone pavement with algae and seagrass cover are used by WRL at night during foraging activities.
- Sub-adults (3-4 years of age) migrate across the deep-water regions of sand and reefs to settle on offshore, deep-water habitats as mature breeding animals. The

migratory path of 'white' WRL is generally from the coast to the edge of the continental shelf, but their movement through different habitats is not known. Migratory immature 'whites' are regularly caught on sandy or silty substrate in deeper water, however, it is unlikely they seek refuge in these habitats due to the lack of shelter and food.

- Breeding females are known to prefer limestone or coral reef habitats throughout their distribution. In the central coastal region, breeding grounds are between 40 to 80 metres deep (Chubb *et al*. 1989).

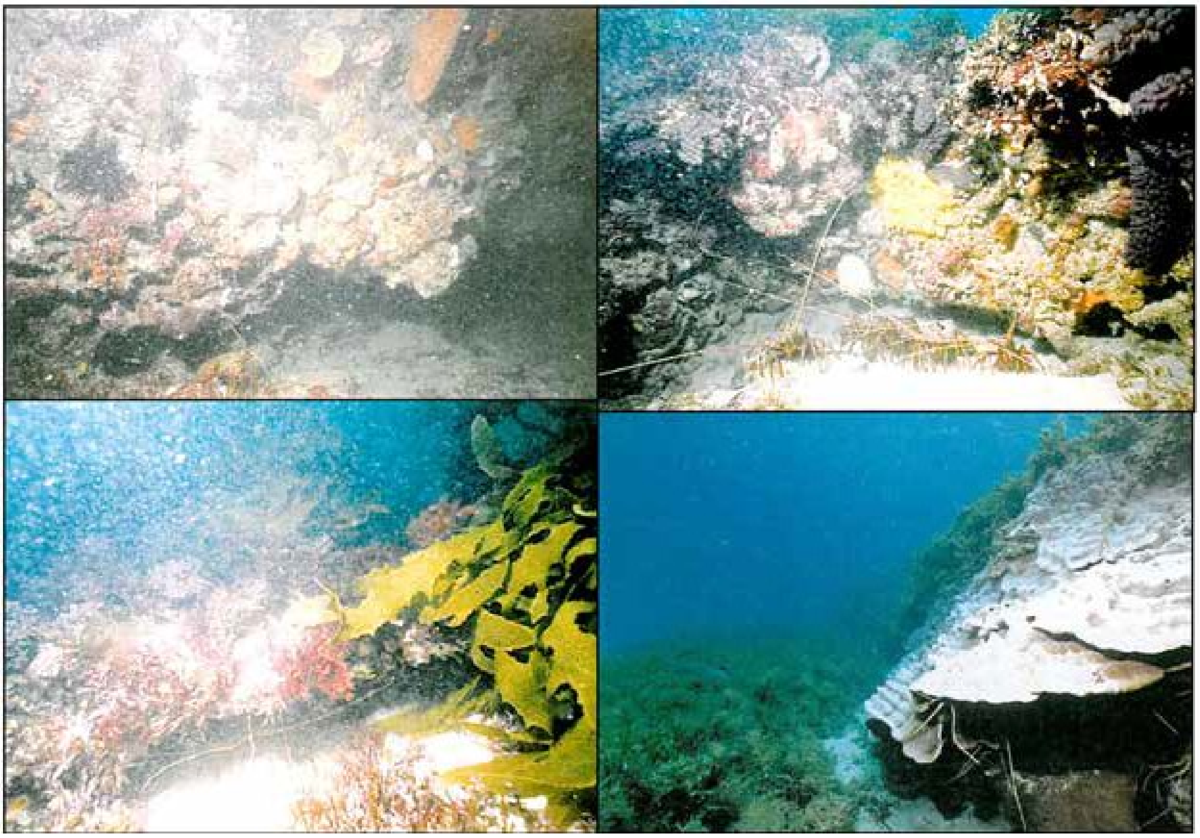

Figure 5.1 Examples of WRL among different habitats (Source: Monaghan Rooke and Robinson 1993, 1994)

5.2 Broad scale benthic habitat mapping the extent of western rock lobster fishery

The distribution of dominant benthic habitats has been mapped by the Department based on analysis of geo-referenced imagery of the seafloor, which has been spatially extended across the west coast bioregion using bathymetry and predictive models (Figure 5-2). A full coverage bathymetric grid exists for Australian waters, produced by Geoscience Australia and the National Oceans Office in 2009, at a resolution of 250 m x 250 m grid (nine arc seconds or 0.0025°) (Figure 5.3). Geomorphic features in the seafloor are retained (Figure 5.3) which is important as modeling of WRL habitats in the deep water closed area off the coast of Leeman showed strong predictive relationships between biological habitat and seafloor geomorphology (Hovey *et al*. 2012). The 250 m national grid was clipped from the Zuytdorp Cliffs, north of Kalbarri down to Flinders Bay in the south and out to the 100 m bathymetry contour. A series of terrain variables were then created to depict features in the landscape at four different scales (250 m, 720 m, 1250 m and 2500 m) which created a secondary dataset for modeling. Seafloor imagery was collected across the west coast bioregion using a variety of methods including towed video, drop video, baited remote underwater videos (BRUVs), autonomous underwater vehicles (AUVs) and cameras attached to WRL pots (PotBOTs). The database consisted of ~200 000 records across the region covering seven substrate categories and five biota categories. The data set was reduced to 4464 records for model development following random subsampling at a minimum distance of 300 m (Figure 5.4). Approximately 1000 additional records were randomly subsampled from the database, excluding the points selected for model development, and were used to validate the final habitat map (Figure 5.5). Dominant benthic biota and substrate categories included in the final habitat map are; sand, reef, kelp, sessile invertebrates, other macro algae and rhodoliths (Figure 5.5). The mixed categories occur where predicted kelp, other macroalgae and sessile invertebrate distributions overlap.

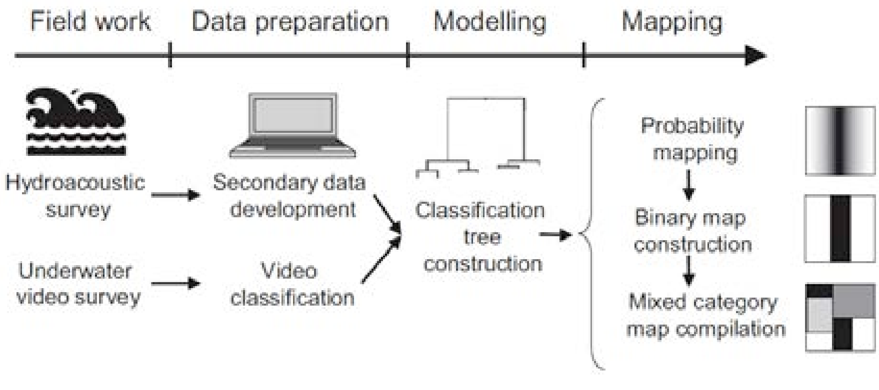

Figure 5-2 Flow chart of the steps from field data collection through mapping in the predictive modeling framework (from Holmes *et al*. 2008).

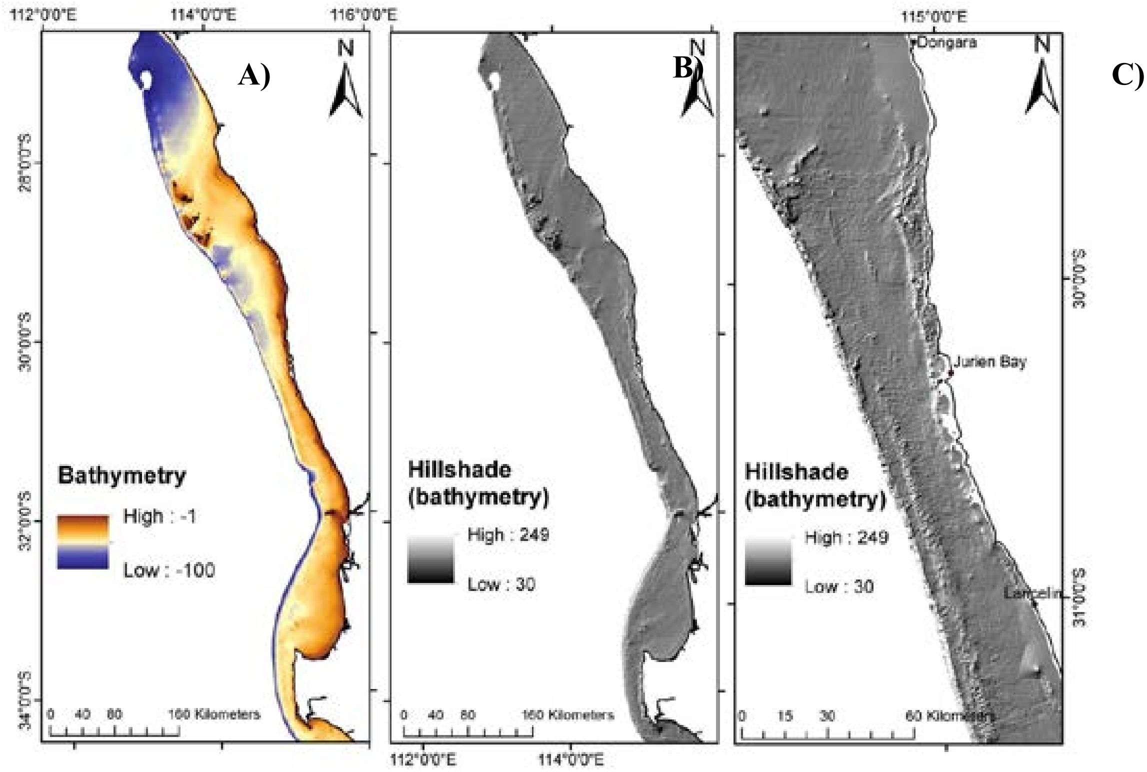

Figure 5.3 The 2009 bathymetric grid of Australia, clipped to the West Coast Bioregion from 1 m to 100 m water depth (a). Resolution of this grid is nine arc second (0.0025°) or ~250 m at the equator (250 m x 250 m pixels). A hillshade was applied to the bathymetry grid, to enhance geomorphic features of the seafloor (b and c).

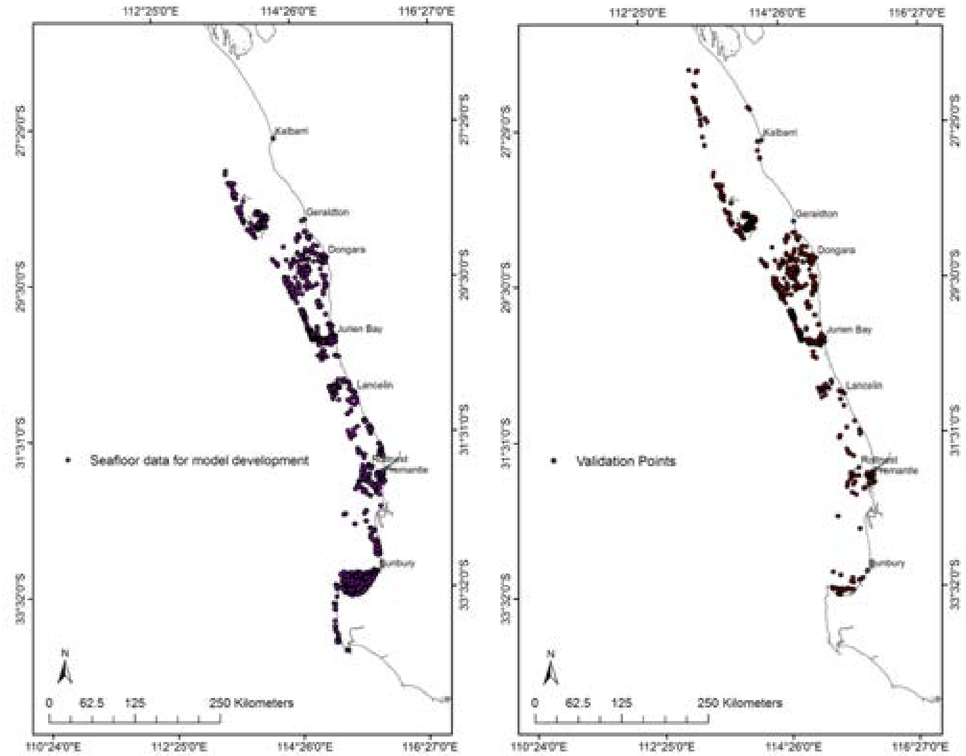

Figure 5.4 Habitat data from seafloor images for model development (left) and map validation (right).

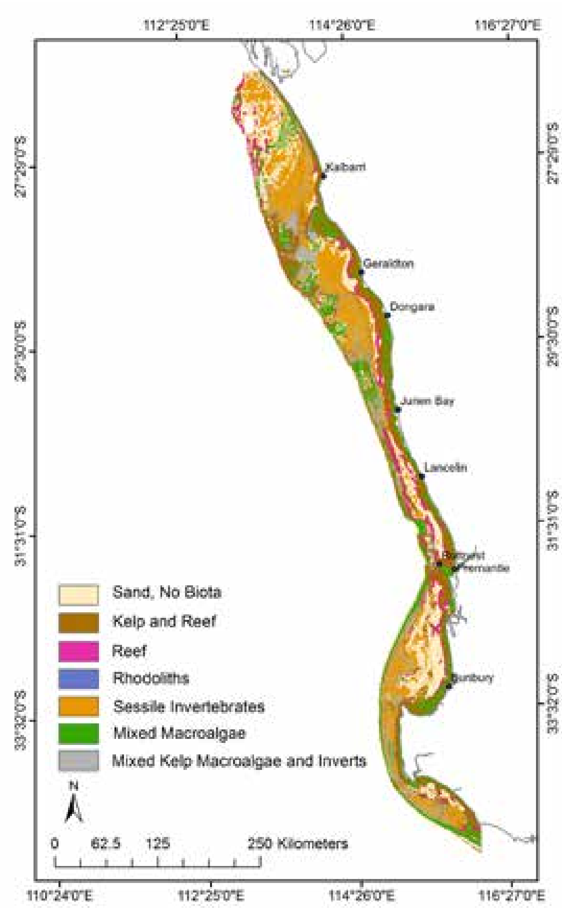

Figure 5.5 Distribution of benthic habitats in the west coast bioregion.

The areal coverage of different habitats in the west coast bioregion have been estimated, with sessile invertebrates having the highest areal coverage (Table 5.1). This habitat is primarily comprised of sponges on sandy or gravel substrates, with ascidians and bryozoans also common. Rhodoliths had the lowest areal coverage, however, this is likely to be underestimated as rhodoliths were not recorded during analysis of imagery. Kelp (*Ecklonia radiata*) covered approximately 5000 km^2 with a clear association between kelp and WRL distribution demonstrated (Bellchambers *et al.* 2010).

Table 5.1 Predicted amount of habitat available within the mapped area of the west coast bioregion.

Habitat	Area (km^2)
Kelp	4,968
Reef	15,863
Sessile inverts	19,741
Mixed Macroalgae	16,424
Rhodoliths	1,632

The accuracy of maps was assessed using contingency tables in the form of error matrices and contained each benthic category for the west coast bioregion habitat map. The overall accuracy of the map was calculated by dividing the total correct by the total number of points in the error matrix. Accuracies of individual categories were calculated, delineating producer's accuracy (dividing total correct by column total) which is the probability that a reference sample (photo-interpreted habitat class) will be correctly mapped and measures the errors of omission (1 - producer's accuracy) and user's accuracy (dividing total correct by row total) which is the probability that a sample from habitat map actually matches what it is from the reference data (photo-interpreted habitat class) and measures the error (1- user's accuracy) (Table 5.2). Kappa coefficient of agreement was calculated which quantifies the agreement between the reference dataset and map classifiers (predicted habitat map) in the error matrix. Generally, values greater than 0.6 are considered good (Czaplewski 1994, Campbell 1996).

Table 5.2 Comparison of estimates of producer and user accuracy for the west coast bioregion benthic habitat map

Estimated accuracy:	**Producer's**	**User's**
Benthic category		
Sand, No biota	87%	83%
Reef	68%	78%
Kelp	68%	66%
Other Macroalgae	78%	61%
Sessile invertebrates	48%	25%
Rhodoliths	22%	15%
Overall accuracy	74%	
Kappa	0.6	

Continued improvement of the accuracy of the predicted distributions will occur as more georeferenced seafloor imagery becomes available. The quality of the bathymetry grid also plays a significant role in the predictability of habitats, with large areas showing poor interpolation results which may be due to limited data being available at the time of development. Incorporating more geo-referenced habitat data from northern, southern and inshore areas will improve the model outputs. The inclusion of more recent bathymetry data, particularly along the inshore areas, will also improve the quality of the predictor dataset. Knowledge gaps in the shallow water habitats (< 30 metres) are expected to be addressed in the coming years with the availability of Light Detection and Ranging (LiDAR) data. LiDAR provides high resolution bathymetric data, with a large portion of the west coast bioregion (Hillarys to Horrocks) being surveyed for the first time in 2016.

Table 5.3 Summary of historical habitat information.

Year	Study Source/ Publications	Region	Scale	Methodology	Classification System
1994	Department of Fisheries (Chubb *et al.* 1994)	Big Bank	Broad	N/A	N/A
2002	Australian Marine Conservation Society WA (Department of Fisheries 2004)	Kalbarri (< 20 m)	Broad	Video surveys, quadrat sampling	Physical substrate Marine flora and fauna
1993	Landcorp (George 1993)	Oakajee (< 20 m), 2 km from shore	Medium	N/A	Integrated biophysical system (6 categories)
1991-1994	Geraldton Port Authority (Monaghan Rooke and Robinson 1993; 1994)	Geraldton (< 30 m)	Medium	Aerial photography Dive surveys	Integrated biophysical system (8 categories)
1988	Abrolhos Islands Task Force (Hatcher *et al.* 1998)	Abrolhos Islands (< 20 m)	Medium/ Fine	Aerial photography, dive surveys	Integrated biophysical system (12 categories)
1995	Marine Science Associates (Marine Science Associates 1995)	Abrolhos Islands (< 20 m)	Medium	Satellite imagery, dive surveys	Integrated biophysical system (8 categories)
1994, 2001	Department of Fisheries (Dibden and Joll 1998; Webster *et al.* 2002)	Abrolhos Islands (20–100 m)	Broad	Towed video transects	Integrated biophysical system (4 categories)
2005	Oceanica (Oceanica 2006)	Abrolhos Islands, Long Island	Broad	Aerial images, snorkel surveys	Integrated biophysical system (15 categories)
2010-Ongoing	Department of Fisheries (Evans *et al*, 2012)	Abrolhos Islands, Wallabi Group	Fine	Satellite imagery, towed and drop cameras	N/A
2014	Department of Fisheries, Midwest Aquaculture Zones	Abrolhos Islands, Zeewijk Channel	Broad	Single beam accoustic	N/A

Year	Study Source/ Publications	Region	Scale	Methodology	Classification System
2008	Marine Futures (Radford *et al.* 2008)	Abrolhos Islands - Pelsaert & Easter Groups (10–80 m)	Fine	Multibeam Hydroacoustics Towed video transect CART, BRUVs	Benthic substrates (4 categories) Benthic biota (4 categories)
1994	Department of Planning and Urban Development (Department of Planning and Urban Development 1994)	Central coast (Dongara to Guilderton) (< 10 m)	Medium	Satellite imagery Dive surveys	Integrated biophysical system (4 categories)
2005	Department of Environment and Conservation (Hill 2005)	Jurien Bay Marine Park (< 20 m)	Medium	Satellite imagery Dive surveys	Major biotic assemblages (5 categories)
2002	Tasmanian Aquaculture and Fisheries Institute (Barrett *et al.* 2002)	Jurien Bay Marine Park	Fine	Visual census Quadrat sampling	Marine flora and fauna assemblages
2009	Tasmanian Aquaculture and Fisheries Institute (Edgar *et al.* 2009)	Jurien Bay Marine Park	Fine	Visual census Quadrat sampling	Marine flora and fauna assemblages
2008	Marine Futures (Radford *et al.* 2008)	Jurien Bay (10–80 m)	Fine	Multibeam Hydroacoustics Towed video transect CART, BRUVs	Benthic substrates (4 categories) Benthic biota (4 categories)
2010 (Ongoing)	Department of Fisheries	Jurien Bay (10–80 m)	Fine	Multibeam Hydroacoustics Towed video transect CART, BRUVs	Varied, CATAMI

Year	Study Source/ Publications	Region	Scale	Methodology	Classification System
1987	Department of Environment and Conservation (Simpson and Ottoway 1987)	Marmion Marine Park (< 10 m)	Medium	Aerial photography Quadrat sampling	Integrated biophysical system (6 categories)
1992	Department of Environment and Conservation (Pobar *et al.* 1992)	Marmion Marine Park (< 10 m)	Medium	Satellite imagery Dive surveys	Integrated biophysical system (5 categories)
2008	University of Western Australia (Ryan 2008)	Marmion Marine Park	Medium	Quadrat sampling	Marine flora and fauna assemblages (% coverage)
1975	Meagher and LeProvost Ecologists (Meagher and LeProvost 1975)	Ocean Reef 3 km from shore	Broad	Dive surveys	Integrated biophysical system (4 categories)
1984	Western Australian Public Works Department (Scott *et al.* 1984)	Sorrento/Hillarys 2 km from shore	Medium	N/A	Marine flora and fauna assemblages (9 categories)
2003	Rottnest Island Authority (Rottnest Island Authority 2003)	Rottnest Island	Medium	N/A	Integrated biophysical system (8 categories)
2009	Murdoch University (Harvey 2009)	Rottnest Island (< 15 m)	Fine	Hyperspectral remote sensing techniques	Integrated biophysical system (6 categories)
2008	Marine Futures (Radford *et al.* 2008)	Rottnest Island (10-100 m)	Fine	Multibeam Hydroacoustics Towed video transect CART, BRUVs	Benthic substrates (4 categories) Benthic biota (4 categories)

Year	Study Source/ Publications	Region	Scale	Methodology	Classification System
1996	Department of Environmental Protection (Department of Environmental Protection 1996)	Southern Metropolitan Region (Yanchep to Mandurah)	Medium	Geoscan airborn multi-spectral scanner	Integrated biophysical system (7 categories)
2006	Department of Environment and Conservation (Department of Environment and Conservation 2006a)	Shoalwater Islands Marine Park	Medium	N/A	Integrated biophysical system (5 categories)
2008	Murdoch University	Swan Marine Region	Fine	Quickbird satellite imagery Drop-camera sampling	Integrated biophysical system (4 categories)
2006	Department of Environment and Conservation (Department of Environment and Conservation 2006b)	Geographe Bay to Cape Leeuwin 10 km from shore	Medium	N/A	Integrated biophysical system (6 categories)
2008	Marine Futures (Radford *et al.* 2008)	Geographe Bay (10-50 m)	Fine	Multibeam Hydroacoustics Towed video transect CART,	Benthic substrates (4 categories) Benthic biota (4 categories)
2008	Marine Futures (Radford *et al.* 2008)	Cape Naturaliste (10-100 m)	Fine	Multibeam Hydroacoustics Towed video transect CART,	Benthic substrates (4 categories) Benthic biota (4 categories)
2007	University of Western Australia	Capes region	Fine	Video surveys Quadrat sampling BRUVs	Marine flora and fauna assemblages (% coverage)

6 Ecosystem

The initial MSC certification process for the WCRLF in 2000 required an ecological risk assessment to be undertaken. Although that process, which was completed in 2001, rated the effects of WRL fishing on the overall ecosystem as a low risk, the lack of research data about the ecological impacts of removing WRL biomass from the environment, particularly from deep-water, remained a concern. An Ecosystem Scientific Reference Group (EcoSRG) was formed in 2003 to provide advice on research directions for determining the effects of WRL fishing on the ecosystem (see Bellchambers *et al* 2012 for a summary).

6.1 Diet and trophic interactions

The WRL has been classified as a generalist feeder with a diet composed of a wide range of plant and animal materials (Joll and Phillips 1984; Edgar 1990a, b; Jernakoff *et al.* 1993; MacArthur 2009). The majority of published studies on diet and foraging of WRL have focused on shallow coastal ecosystems (< 5 m depth), such as Cliff Head and Seven Mile Beach in Western Australia (Joll and Phillips 1984; Edgar 1990a, b; Jernakoff *et al.* 1993), while deep-water habitats (> 35 m depth) have until recently received little attention.

Results from WRL dietary studies have revealed consumption of gastropods (e.g. *Cantharidus lepidus* and *Pyrene bidentata*), molluscs, polychaetes, small crustaceans, bivalves, chitons, sipunculid worms, non-coralline algae, seagrass, brachyuran crabs, ascidians, sponges, pycnogonids, hydrozoans and echinoids (Waddington et al. 2008). Western rock lobsters also consume large quantities of coralline algae, in particular *Corallina cuvieri* and *Metagoniolithon stelliferum* that are epiphytic on stems of the seagrass *Amphibolis*. It has been suggested that coralline algae may contribute both to the nutrition of WRL, in particular in macroalgae dominated pavement and sand habitats (MacArthur 2009), as well as to the uptake of calcium to the exoskeleton of early intermoult juvenile animals (Joll and Phillips 1984).

Although a number of predators may consume WRL, few studies have investigated the role of predation on the WRL in the food web. Howard (1988) identified a range of fish species that prey on small post-puerulus (< 26 mm CL), including sand bass (*Psammaperca waigiensis*), sea trumpeter (*Pelsartia humeralis*), brown-spotted wrasse (*Pseudolabrus parilus*), gold-spotted sweetlips (*Plectorhyncus flavomaculatus*), breaksea cod (*Epinephelides armatus*) and the Chinaman cod (*Epinephelus homosinensis*). Sand bass was considered the most important predator with almost 16 % of collected individuals containing WRL. Brown-spotted wrasse and sea trumpeter were also abundant during the study, and it was suggested that these fish species could be responsible for large reductions of small post-puerulus within the area.

The vulnerability of WRL to predation is related to the size of individual animal, with small fish predators consuming large numbers of WRL within their first year of settlement. The

extent of mortality of juvenile WRL due to predation is largely unknown due to a lack of information on the natural densities of both fishes and WRL on shallow near-shore reefs. However, it has been suggested that the annual removal of juveniles by fish could be as much as thousands of WRL per hectare, suggesting that predation may be an important factor limiting the survival of this size class. As WRL increase in size, predation decreases. Larger predators such as octopus, large fish and sea lions are thought to prey on larger animals, although the limited data available for these predators suggests that no species relies completely on the consumption of WRL.

WRL act as secondary consumers in shallow and deep-water habitats as they derive much of their growth from benthic animal prey that feed on primary producers (Joll and Phillips 1984; Edgar 1990a; b; Jernakoff *et al.* 1993; Waddington *et al.* 2008; MacArthur 2009). The WRL are also grazers in shallow-water habitats where significant quantities of coralline algae and seagrass are consumed (Joll and Phillips 1984; Edgar 1990a; b; Jernakoff *et al.* 1993; MacArthur 2009). Shallow water WRL also consume large numbers of sponges and ascidians.

For a detailed summary of diet and trophic of the WRL see Bellchambers *et al* (2012), relevant historic research listed in Table 6.1.

Table 6.1 Summary of research investigating the diet and trophic role of western rock lobsters.

Author	Date	Location	Depth	Habitat	Methods	Size-class	Trophic findings	Remarks
Joll and Phillips	1984	Cliff Head and Seven Mile Beach	< 5 m	Open reef face, reef ledge and cave habitats	Gut content	Juveniles	Foliose coralline algae (predominantly two spp.) important at Seven Mile Beach. Molluscs important at both sites, but volumetric contribution fluctuated between sites and seasons.	Fluctuations in a small number of mollusc spp. at Cliff Head responsible for seasonal variation at that site. Juveniles had higher growth rates at Cliff Head.
Howard	1988	Seven Mile Beach	2-4 m	Seagrass covered limestone reefs and open habitats	Gut content of fish caught by gill net and rotenone	Small post-puerulus (< 26 mm).	Sand bass (*Psammaperca waigiensis*), sea trumpeter (*Pelsartia humeralis*) and brown-spotted wrasse (*Pseudolabrus parilus*) most important predators of post- puerulus.	The vulnerability of lobsters to predation strongly related to size (greatest predation on 8-15 mm CL). Cryptic habits of newly-settled stages related to predation risks.
Edgar	1990a; b; c	Cliff Head and Seven Mile Beach	< 5 m	Amphibolis, *Halophila* and turf habitats.	Gut content	Juveniles (25-85 mm)	Cantharidus lepidus consumed in high quantities when seasonally abundant at Cliff Head and polychaetes consumed in large numbers when seasonally abundant at Seven Mile Beach.	Lobsters can significantly reduce epifaunal gastropods densities in seagrass meadows adjacent to reefs.

Author	Date	Location	Depth	Habitat	Methods	Size-class	Trophic findings	Remarks
Jernakoff et al.	1993	Seven Mile Beach	< 5 m	Natural habitats dominated by seagrass (*Amphibolis* spp. and *Halophila ovalis*/ *Heterozostera tasmanica*) and artificial collectors	Gut content	Post-puerulus juveniles within 1st year after settlement, (< 25 mm)	Dominant dietary items were coralline algae, molluscs and crustaceans. Coralline algae important to post molt stages. Proportionally, post-pueruli consume less coralline algae and more molluscs than the larger juveniles (> 25 mm) at the same sites.	Post-pueruli not foraging in turf on top of reefs (unlike older age classes). Molluscs greatest component of diet of post-pueruli on collectors (Possibly because coralline algae not available on collectors).
MacArthur et al.	2007	South West Marine Region	Shallow and deep		Synthesis		Reviews previous trophic work. Includes comments on the prey and predators of western rock lobster. Highlights gaps in knowledge of trophic relationships in deep-water.	Comments on the potential of predation by different species including small sharks and sea lions.
Waddington et al.	2008	Lancelin, Jurien Bay, Dongara - mid-shelf coastal	35 - 60 m	Ecklonia-dominated reef	Gut content & stable isotopes	53 to 145 mm CL	Main dietary items included crabs, amphipods/isopods, lobster bait and smaller amounts of foliose red algae, sponges and bivalves/ gastropods. Gut content analysis suggested crabs important – (slow evacuation rate for hard shelled items). Stable isotopes suggest bait important at certain times (varies seasonally).	Trophic position of lobsters differed significantly between locations and ranged between 1.90 at Dongara and 2.18 at Lancelin. Jurien Bay lobsters were intermediate (all higher than shallow-water where algae is important).

Author	Date	Location	Depth	Habitat	Methods	Size-class	Trophic findings	Remarks
MacArthur	2009	Jurien Bay Marine Park	< 15 m	Seagrass or macroalgae/ sand	Gut content & stable isotopes	36 - 98 mm	Type of habitat surrounding a reef was a better predictor of *P. cygnus* diet on a landscape scale than site, sex, carapace length or month. Animal prey including mobile invertebrates important to lobster nutrition and preferentially assimilated over articulated coralline red algae. Trophic position of lobsters ranged between 1.50 and 1.60.	Macro-algae, rather than seagrass, most likely autochthonous energy source driving lobster production in shallow coastal waters, but seagrass likely plays an important role providing lobsters with mobile invertebrate prey and shelter whilst foraging. Bait and cannibalism may have a more significant role for lobster nutrition in shallow environments than previously thought.
Waddington and Meeuwig	2009	South West Marine Region	Shallow and deep		Modelling - mass balance		Abundance of natural diet items on the benthos sufficiently explain the observed growth of lobsters, with bait contributing max 13% of lobster food requirements over the whole ecosystem. Contribution of bait varies spatially and temporally reflecting uneven distribution of fishing effort (may be ca 35% during some months of the fishing season).	Concludes that it is likely that the effects of bait addition on ecosystem function are more widespread than lobster production.

Author	Date	Location	Depth	Habitat	Methods	Size-class	Trophic findings	Remarks
Lozano-Montes et al.	2011	Jurien Bay Marine Park	Shallow water	Various	Modelling - Ecopath	Various including post-puerulus and adults	Many functional groups, including rock lobster, are influenced by changes to biomass of benthic groups e.g. *Ecklonia*. (due to food and shelter *Ecklonia* habitats provide). Changes to lobster biomass affect the simulated biomass of key prey groups and predators of lobster.	Based on diet literature and expert opinion/workshops. The simulations suggest that the structure of this ecosystem is characterized more by bottom-up than top-down processes i.e. benthic primary production is a major limiting factor.
Metcalf et al.	2011	Jurien	Deep water	Ecklonia-dominated reef	Modelling - qualitative	Mature / near mature	Conceptualises trophic relationships in deep-water benthic ecosystem by synthesizing available diet literature. Results suggest general fish and small crustaceans have potential as indicators of ecosystem effect of lobster fishing.	Qualitative modelling used to identify potential indicators of ecosystem change. Results also highlight gaps in trophic knowledge, i.e. relationships between octopus and lobster fishery.
Bellchambers and Pember	2014	Jurien Dongara	Deep water	Reef	Gut content Next Gen-DNA	Mature Large males 90-140mm	Brachyuran crabs and Paguroid hermit crabs dominate diets of large lobsters in deep water.	Next Gen sequencing of gut contents of large lobsters collected from demersal gill nets. Techniques showed promise but study compromised by lobsters feeding on gill net caught teleosts and elasmobranches.

Moore *et al.*	Ongoing (WA MSI)	Metropolitan region. Areas of contrasting lobster abundance (sanctuaries)	< 15 m	Seagrass beds (*Amphibolis* spp.)	Gut content and stable isotopes. Seagrass assemblage structure.	up to 112 mm	Assemblage structure noisy (highly variable between replicates). Density effect not apparent on whole assemblage, only small number of molluscs in some months.	Appears to be negative relationships between lobster density and mollusc abundance (trochids). Density of lobster does not appear to affect diet (based on stable isotope signatures).

6.2 Areas Closed to Fishing

6.2.1 Scientific Deepwater Research Closure - Leeman

In 2003 the EcoSRG, among a range of priority information gaps, identified the need to collect basic ecological information to determine if changes in WRL density and size structure, due to fishing, had caused significant changes in habitat structure and benthic community composition in deep water. A second risk assessment identified that the potential ecological impacts of WRL fishing, while remaining a low risk within shallow waters, were a moderate risk within deep water regions. Therefore, additional research was required to address these knowledge gaps.

The EcoSRG recognised that any new research within deep water regions needed to occur in a structured manner and devised a strategic framework, which recommended that the initial work should focus on identifying and observing any ecosystem patterns associated with levels of fishing pressure, WRL population size structure and benthic structure. The patterns observed across these gradients were expected to provide some information on these relationships and assist in determining whether research using fished versus unfished areas was necessary within these regions.

An FRDC (2004/049) project provided the critical baseline data on the relationships between the abundance and size distributions of WRL and the different benthic habitats located in deeper waters (Bellchambers 2010). This project also provided preliminary information on the trophic role of WRL within these depths. However, despite the identification of gradients in the abundance of WRL within similar habitats, this technique ultimately proved ineffective in providing sufficient information to clarify these relationships to reduce the risk level. A risk assessment of the WCRLF, completed in 2007, determined that there was a moderate risk that the removal of WRL biomass may be altering the relative abundance of species within deep water communities. To meet the 2006 Action Plan for MSC recertification, an adequate understanding of the impacts of the WCRLF on trophic linkages between WRL and their predators and prey at the main stages of WRL life history was required. Given the outcomes of this assessment, it was recognised that research in deep water would have to compare fished and unfished areas using research closures. This would require the establishment of suitable fished and unfished areas, plus the collection of baseline information to enable such ongoing comparisons to occur.

An industry closed-area working group, reporting to the Rock Lobster Industry Advisory Committee (RLIAC), was formed in August 2007 with the specific aim of identifying and ranking areas on their potential to become closed areas. The working group nominated a total of six locations, between the Houtman Abrolhos Islands and the south west Capes region, as potential sites for a closed area. Each location was assessed against the selection criteria formulated by the EcoSRG. The criteria were that the closed area must be:

- representative of WRL demographics,
- central to and generally representative of the fishery,
- accessible,
- representative of deep water WRL habitat based on information obtained from previous habitat mapping work,
- an optimum location for enforcing compliance of the closure, and
- an appropriate size to assess the impacts of lobster biomass removal.

Additional funds from FRDC (FRDC 2008/013) were obtained to identify and assess suitable fished and unfished reference zones, develop qualitative trophodynamic models and provide cost effective methods to measure effects of WRL biomass removal on the deep water ecosystems. Two locations were short listed, the southern part of the A zone and 30°S latitude line, for which towed video habitat information was collected. On the basis of the benthic habitat information, an in-principle agreement was reached for the location of the proposed area around the 30°S latitude line, demarcating the boundary between Zone B and Zone C. A systematic potting survey was then implemented to determine if the demographics of WRL within and surrounding the proposed site were representative of fished habitats.

A scientific advisory group (SAG) was formed in February 2009 to independently review the methods to be used in the associated project, including the size and position of the closed area. After reviewing the recommendations of the closed area working group and information provided by the Department on the habitat and WRL demographics, the SAG was confident that WRL demographics in the proposed area (30°S latitude line) were representative of the fishery and comparable to those found in the nearby Jurien independent breeding stock survey site.

Negotiations between representatives of the Western Rock Lobster Council (WRLC), RLIAC, SAG and the Department reached a compromise of a 12 nm^2 area located on the border of B and C zones (Figure 6.1). This area, the Leeman Scientific Closed Area on the 30°S latitude line, was officially closed to commercial WRL fishing on the 15 March 2011 for a period of five years, after which the arrangements will be reviewed.

Subsequently a number of projects commenced to establish baselines in Leeman Scientific Closed Area and nearby fished areas against which the potential impacts on deep water ecosystem of WRL biomass removal by fishing can be quantified. Initial abundance data from the closed area suggests a rapid increase in WRL, particularly mature males.

Conversely, ecosystem impacts of fishing can often be diffuse and the full impact of fishing on the ecosystem may take an extended period to manifest (i.e. >10 years). Therefore it is essential that a range of ecosystem components i.e. target species (WRL), benthic habitats and indirect ecosystem indicators (small fish), continue to be monitored through time.

An extension of the closed area for 18 months has been obtained and the Department continues to recommend that the Leeman Scientific Deepwater Closure remains closed for a further of five years (until 2021).

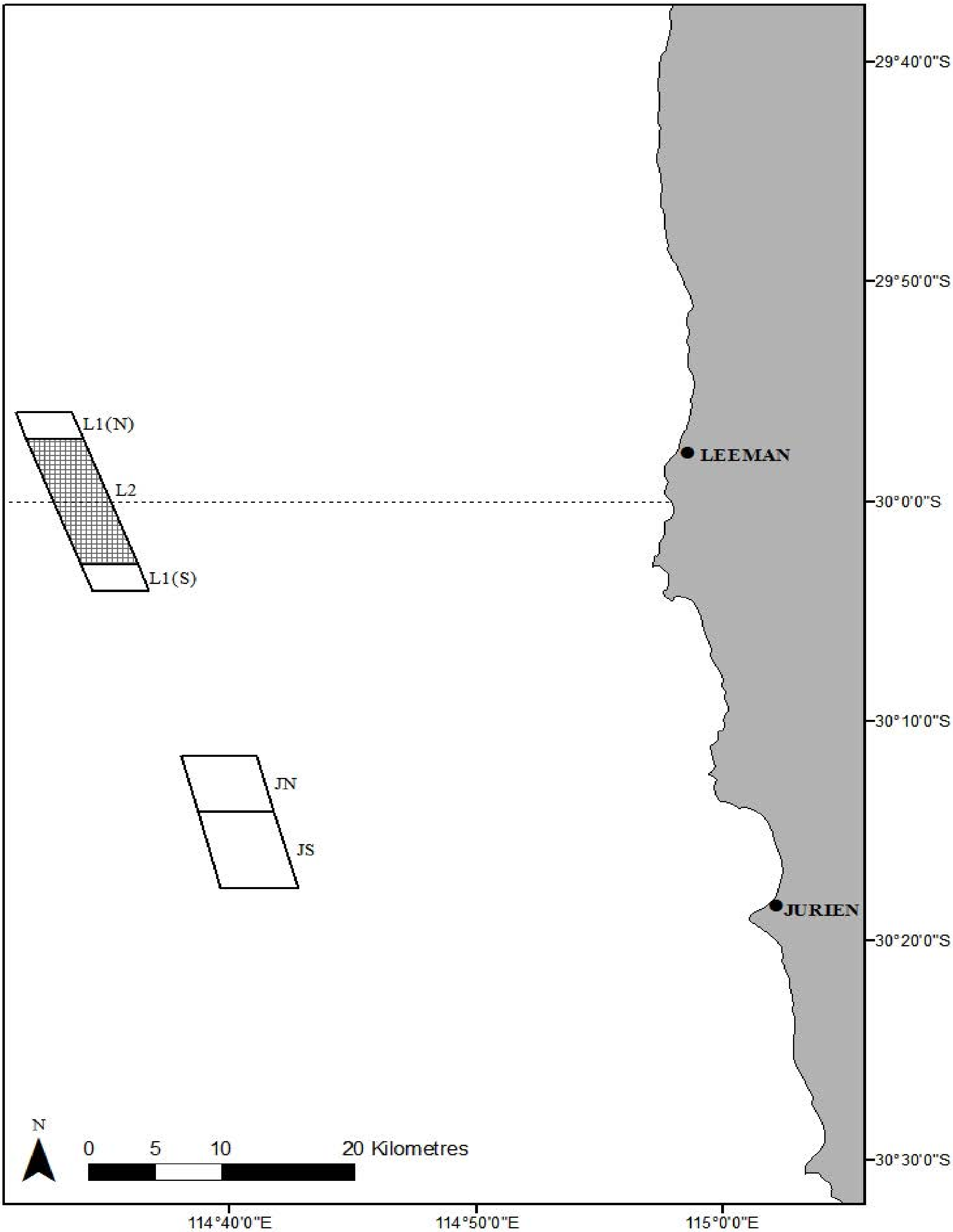

Figure 6.1 Area closed to WRL fishing. 3 nm above the 30° S latitude line (B Zone), 3 nm below 30° S latitude line (C Zone) and 2 nm West – East from the 100 m contour line.

6.2.1.1 Target species (*P. cygnus*)

There was an increase in WRL in the deep water at all sites, regardless of protection status (Figure 6.2). The period (2008-2012) corresponds with below average recruitment and substantial management changes in the WCRLF, including a move from input control to individual quotas. The increase in WRL numbers in deep water demonstrates the success of management initiatives to retain mature WRL biomass. Catch rates of WRL have increased in the Leeman closed area (L2) and each of the fished areas (L1, JN and JS) but the increase was larger in the closed area. While the difference between closed and fished areas could be observed in the total abundance of WRL, it was more distinct for WRL over the legal size and particularly legal sized males (Figure 6.2). This is consistent with a closure effect as the fishery selects for mature males, mature females can only be retained at certain times of the year when they are not reproductive. A steady increase in catch rates of undersize WRL since 2011 reflects better puerulus settlement in recent years. The larger increase in undersize catch rates at Jurien than at Leeman is also reflected in the size structure (Figure 6.3).

The size and sex compositions of WRL at Jurien and Leeman were similar between 2008 and 2010 (data not shown) suggesting that the sites were comparable in terms of suitability for WRL. However, in 2012 there was a substantial recruitment of sub-legal sized animals at the Jurien sites that was not observed in the Leeman closure (Figure 6.3). Only small numbers of recruits were observed at the Leeman fished site (L1). A similar recruitment of sub-legal WRL at Jurien was also observed in 2015 (Figure 6.3). While differences in sub-legal sized WRL at Jurien and Leeman may be attributed in part to habitat, it is also likely that some of the differences may be related to density dependent factors influencing recruitment or the high number of WRL, particularly large males, may deter sub-legal animals from entering pots in the Leeman closure and to a lesser extent in the Leeman fished area. These results serve to highlight the importance of the continued closure and monitoring to assist with assessing the potential ecosystem effects of fishing.

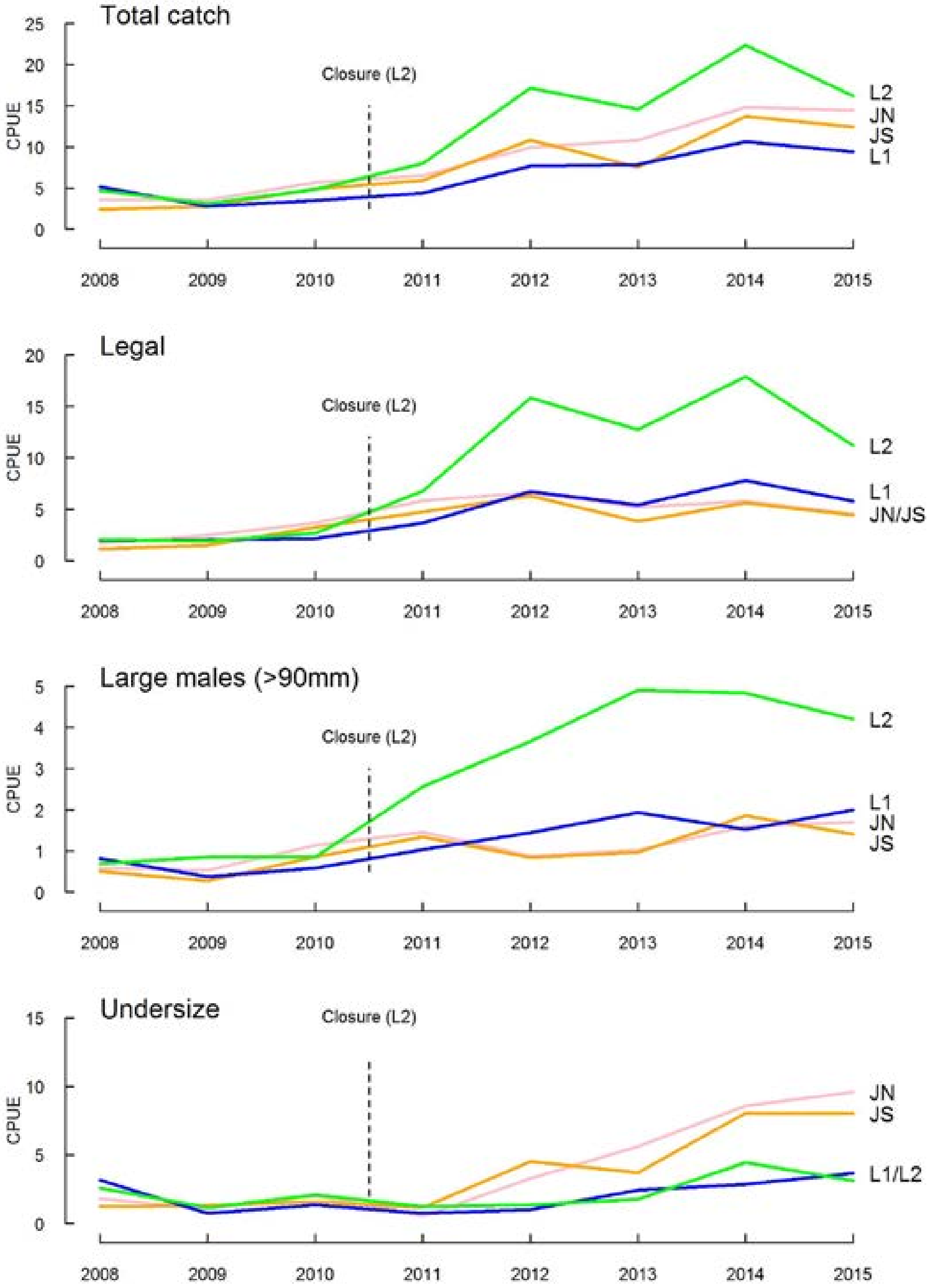

Figure 6.2 Catch rates (*n* per potlift) on reef between 2008 and 2015 at Jurien (JN; pink and JS; orange), the fished area adjacent to the closure (L1; blue), and within the closure (L2; green) for all, legal, large male and undersized lobsters. Dotted vertical line denotes when the closure was established, prior to the 2011 sampling period.

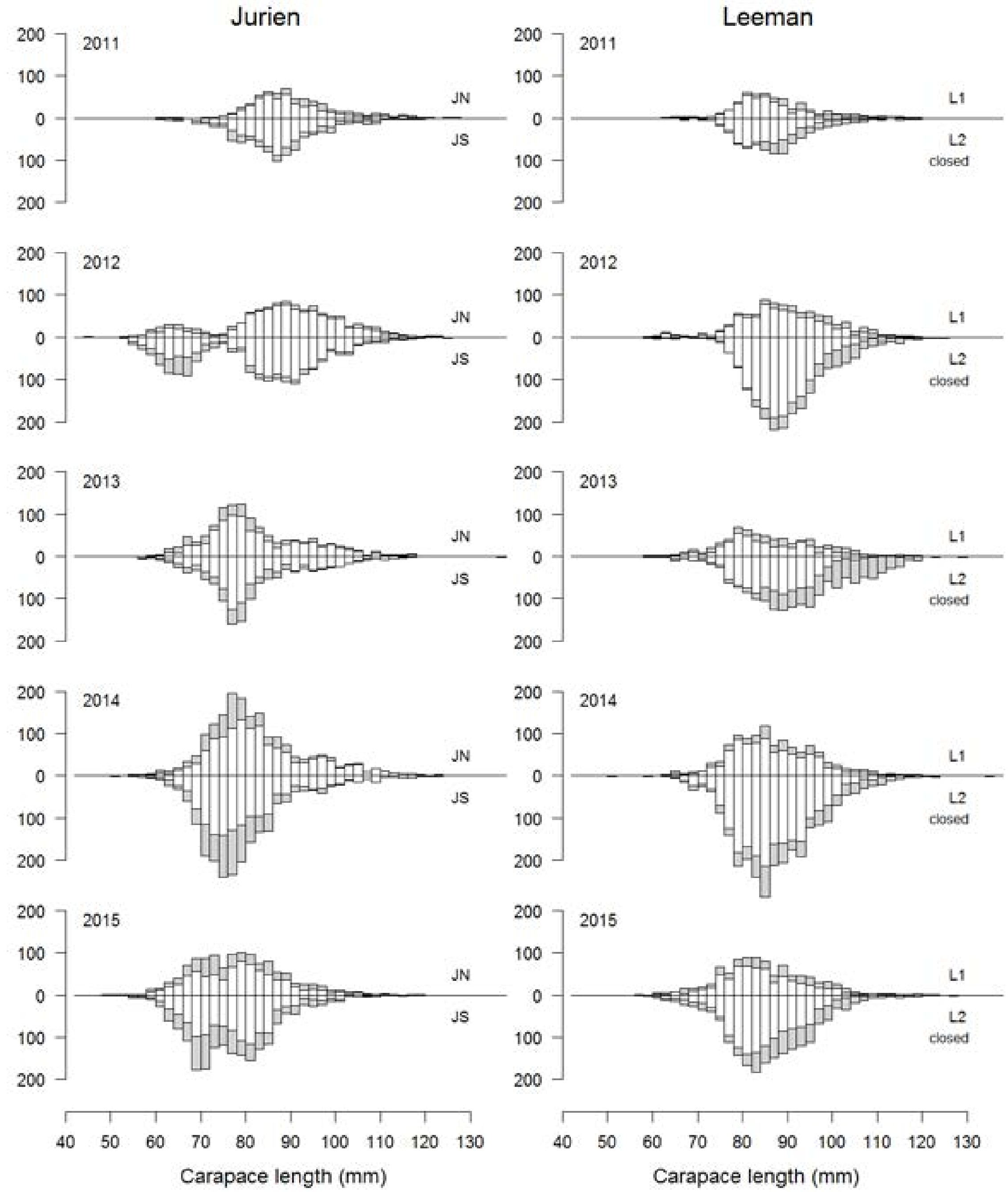

Figure 6.3 Size composition (CL mm) of male (filled bars) and female (un-filled bars) lobsters at Jurien (left) and Leeman (right) between 2011 and 2015. In each year the two sites at each location (i.e. JN and JS or L1 and L2) have been plotted above or below the x axis. Note that L2 became closed to fishing prior to sampling in 2011.

6.2.1.2 Benthic Assemblages

Surveys to collect quantitative data on the composition of benthic habitat assemblages were undertaken in 2015. The data was obtained using high resolution cameras attached to a live feed tow video system corrected for position to a vessel mounted differential GPS. Representative ~500 m^2 blocks were stratified into zones with two zones in the Leeman closure (two in the northern 'B Zone' and two in the southern 'C Zone') and two in the comparable fished ground located on the Jurien independent breeding stock survey (IBSS) sites. The survey blocks were chosen based on capturing similar habitats between zones and repeating previously surveyed tow video and autonomous underwater vehicle surveys. Fine scale benthic data was collected by conducting multiple transects along the full length of the survey blocks, equating to ~500 m x 5 m belts. Analysis of the images is currently being undertaken to estimate benthic assemblage for both temporal and spatial comparisons within and between fished and non-fished deep water WRL habitats.

6.2.1.3 Fish Indicators

Qualitative modeling indicated that small fish may be potential indicators of ecosystem change associated with removal of WRL through fishing (see Metcalf *et al.* 2011, Bellchambers and Pember 2014). A survey using stereo baited remote underwater video sampling in 2011 provided a baseline for fish communities inside and outside the Leeman closure and investigated capacity to quantify change in populations of fish indicators (Langlois *et al.* in press). This work confirmed that the fish assemblages within the two areas (Leeman closure vs Jurien fished area) were comparable. However, two indicator species were significantly more abundant in the closed area, the pigfish *Bodianus vulpinus* and the butterflyfish *Chaetodon assarius,* with both associated with deeper sites within the closure. The study also found that the indicator species displayed strong habitat associations with macro algae dominate sites. The study also showed that such indirect trophic consequences of changes in WRL abundance would take time (i.e. >10 years) to become apparent and may be subtle. Therefore future, cost effective, monitoring concentrating on macro-algal habitats is required to be repeated at multiyear timeframes. The first of such surveys, a second time point, was undertaken in 2014. Preliminary data from this temporal comparison showed a general trend of decreased biomass across most indicator fish species, across all sites, between 2011 and 2014 with the exception of the western king wrasse *Coris auricularis.* Sampling showed no significant spatial or temporal trends for trophic indicator fish (see Metcalf *et al.* 2011) abundance between the closed and open area between 2011 and 2014. This result is expected with the timeframe of closure (5 years) currently too short to detecting significant change in fish structure.

6.2.2 Big Bank

The deep water area to the north of A Zone known as Big Bank (Figure 6.4) was closed to commercial fishing in February 2009 and remains closed. The Big Bank region was initially closed to fishing on the 24th of February 2009 as a precautionary measure in response to (a) low levels of puerulus settlement recorded in 2008/09, and (b) industry's concern of recent poor catch rates in this region at that time and hence a poor breeding stock. Protecting this area from fishing was intended to aid recovery of the breeding stock by protecting resident WRL and allowing for future migration to the area.

In conjunction with annual breeding stock surveys, independent surveys were conducted in the Big Bank region since 2009. In 2016, extremely limited commercial fishing was permitted in the area under an exemption. This permitted the regulation on the amount of effort occurring in the area, as well as providing a number of conditions relating to additional information that skippers were required to record while fishing under this exemption. Fishers were also not permitted to fish in an area within Big Bank that contained areas monitored during the independent breeding stock surveys (Figure 6.4).

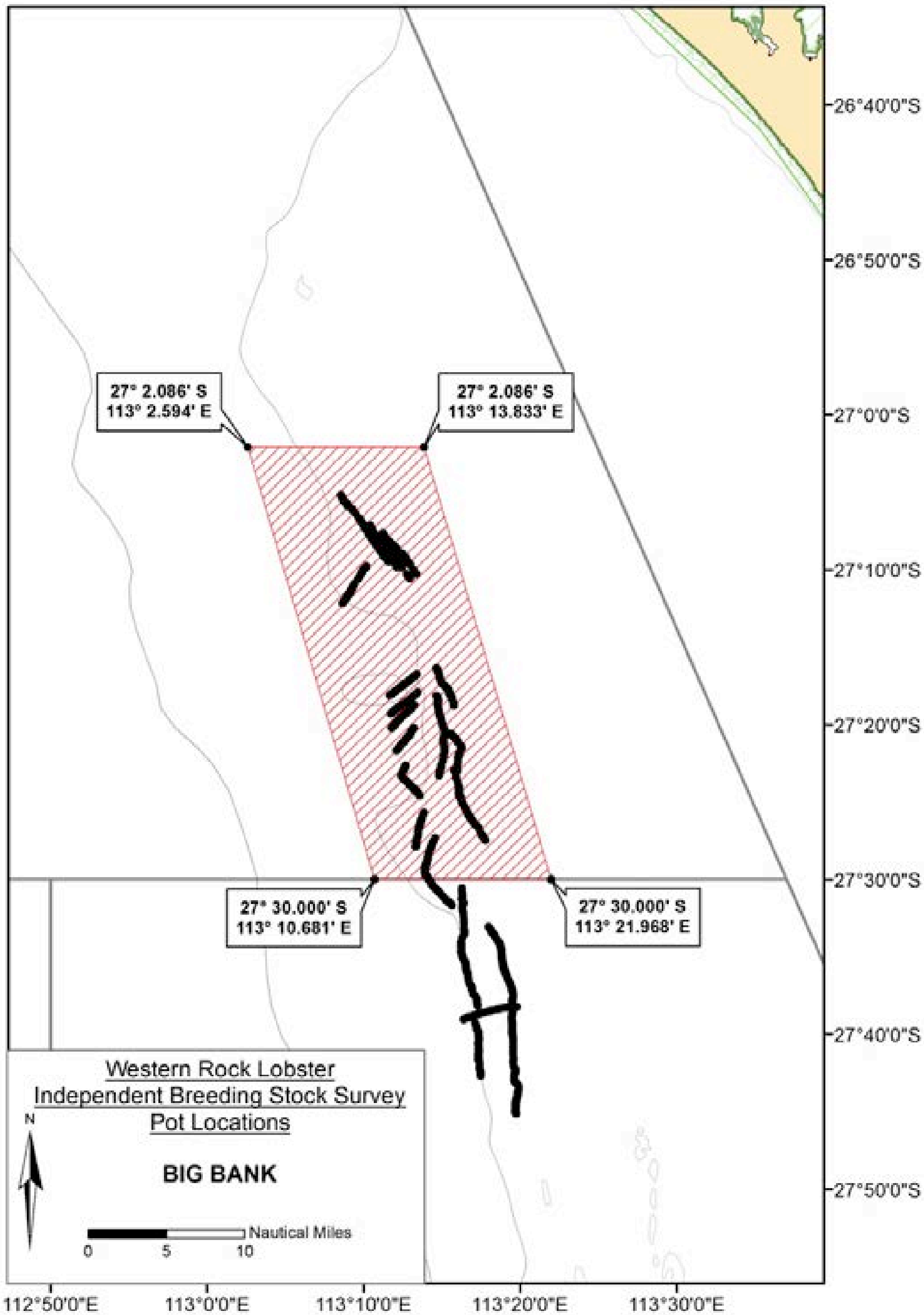

Figure 6.4 Big Bank region showing independent breeding stock marks (black dots) and area closed for research (shaded) during limited exemption covered commercial fishing activities

There has been an increase in the breeding stock levels recorded in Big Bank in the most recent survey, though it has not reached the levels recorded in 2011 (Figure 6.5). This is thought to be a possible artefact of catchability variation between these surveys. Additional work is being undertaken to better understand this variation such that it can be more accurately accounted for in future assessments of the area's performance.

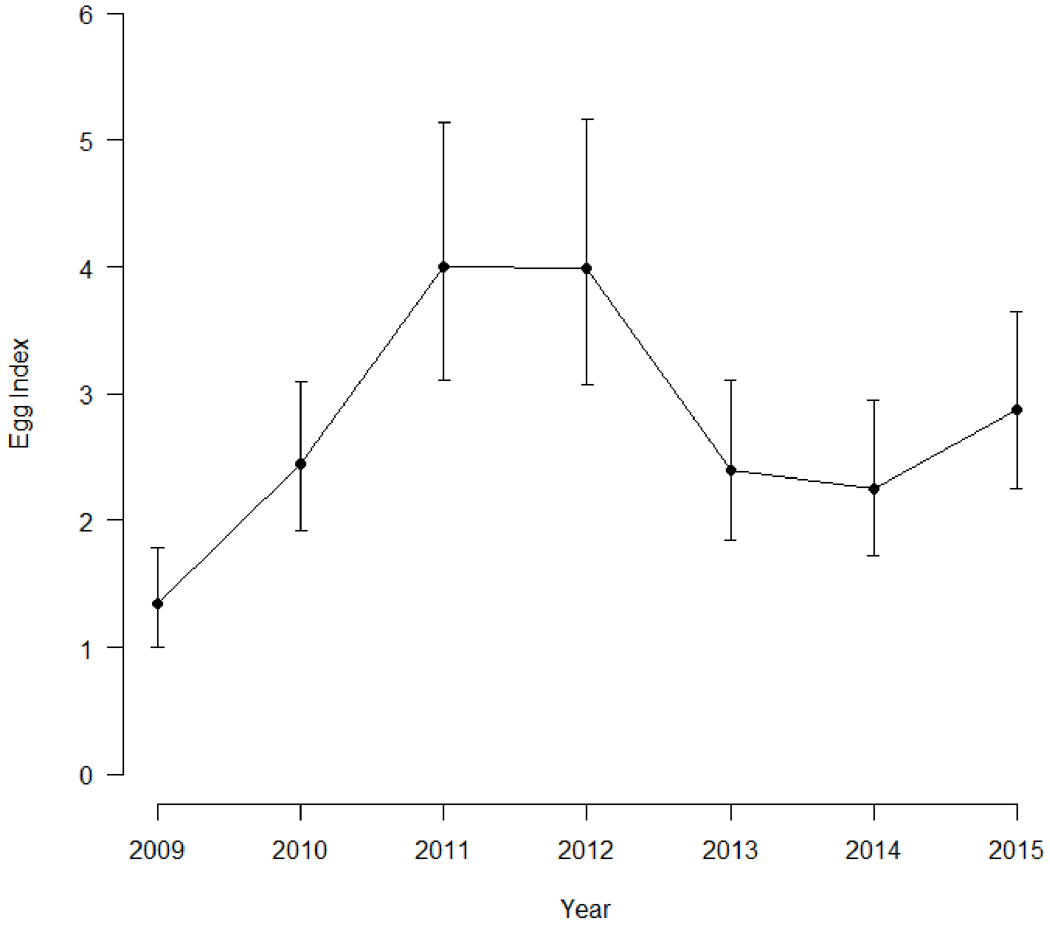

Figure 6.5 Annual egg production index for Big Bank as determined by independent breeding stock surveys

7 Other Relevant Research

7.1 Houtman Abrolhos Islands

There are several ongoing studies being conducted by the Department to assess the benthic habitats and determine the extent and impact of WRL potting on the sensitive habitats of the Houtman Abrolhos Islands (Abrolhos Islands).

7.1.1 Habitat mapping

In 2010, the Department produced series of benthic habitat maps of the shallow water (<25 m water depth) of the Wallabi Group of the Abrolhos Islands using remote sensing techniques (Figure 7.1) (Evans *et al.* 2012). In 2016, this study was repeated to assess the feasibility of using remote sensing maps to detect and quantify temporal changes in habitat composition over medium to large spatial areas. Data from this comparative study is currently being analysed. Results from this study will assist with assessing the feasibility and potential development of appropriate methodology for long term ongoing surveys of this type for the Abrolhos Islands. If successful this methodology could also be also be investigated for use at indicator sites along the coastal shallow water environments of the west coast bioregion.

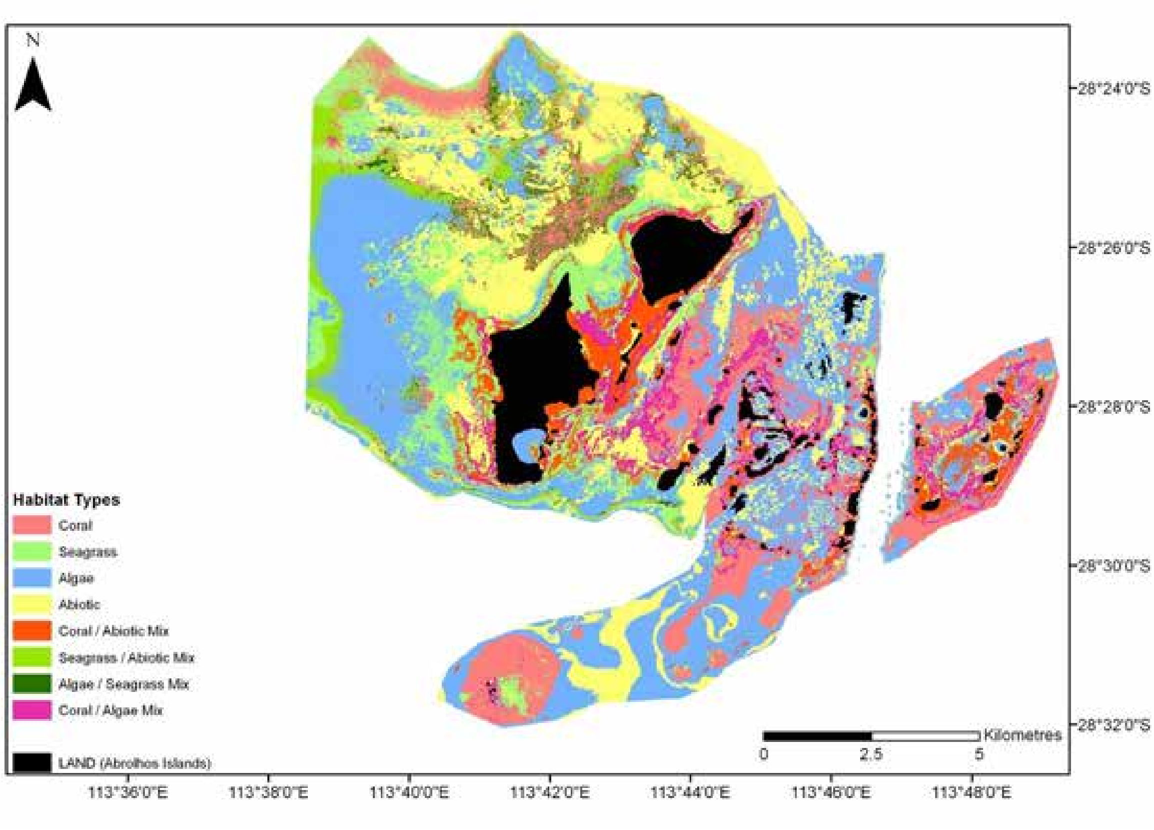

Figure 7.1 Benthic Habitat Map of the Wallabi Group, Abrolhos Islands.

In 2015, the Department undertook habitat assessments and benthic mapping of the proposed Mid-West Aquaculture Development Zones (MWADZ) in the Zeewjk channel of the Abrolhos Islands (Figure 7.2). Data to inform the benthic habitat map was collected using a

Biosonic MX digital single beam echo sounder. Data was collected in a xyz configuration of latitude, longitude and echo return. The interpolated habitat map of the benthos for the MWADZ locations provide a 60% probability of habitat occurrence (Figure 7.2). The map was validated using 456 separate live feed camera drops throughout the MWADZ locations. Benthic mapping from this process overlapped some areas of multi-beam hydro-acoustic mapping from the Marine Futures Project (Radford *et al.* 2008). Collaborations are ongoing with the University of Western Australia to compare multi-beam and single beam hydro-acoustic methods for detecting change in habitats.

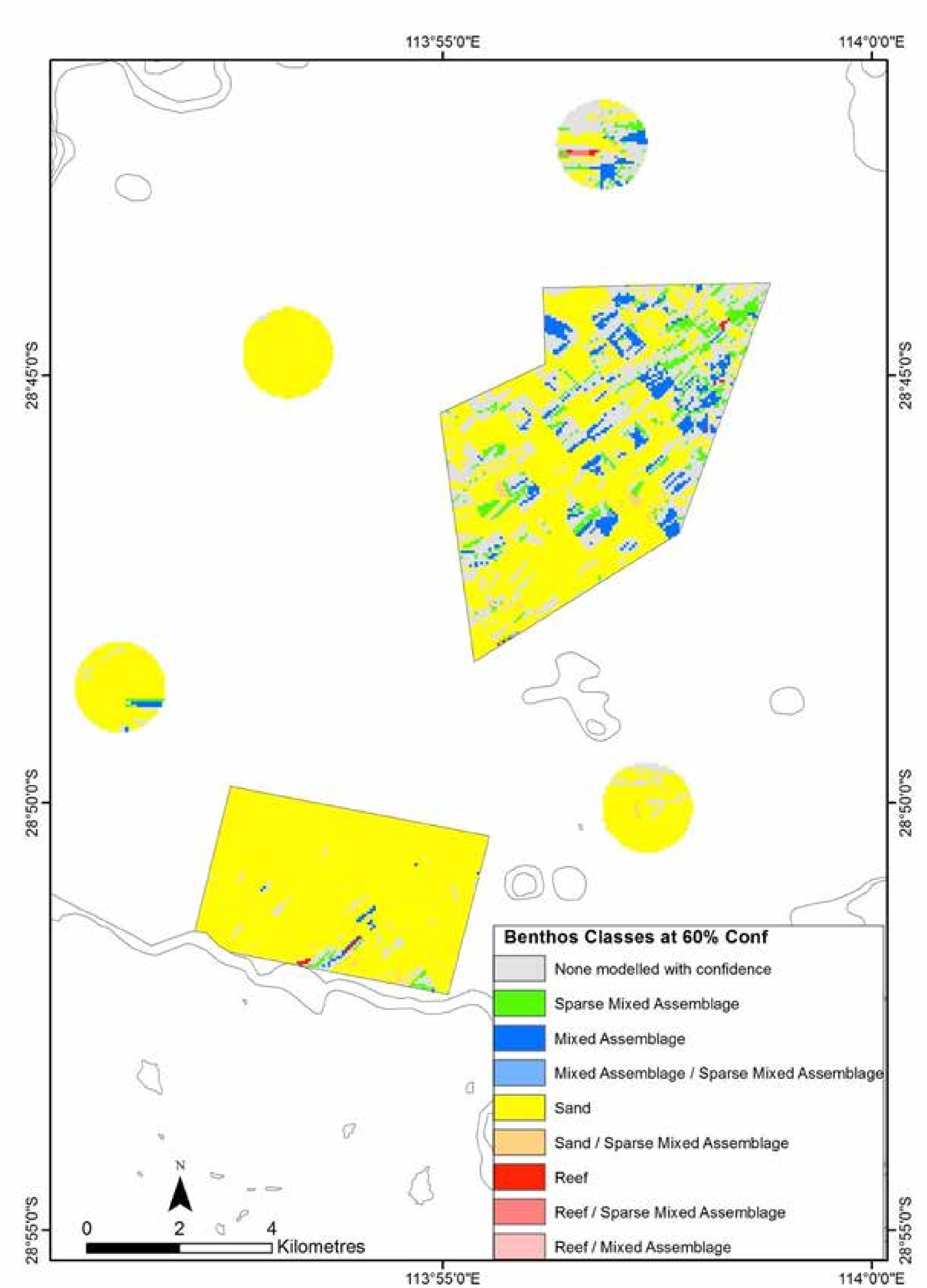

Figure 7.2 Single beam hydro-acoustic habitat map of the Zeewijk Channel, Abrolhos Islands

7.2 PotBOT – Fishery Dependent Habitat Data Collection

This research is providing a cost effective temporal and spatial understanding of the types of benthic habitats that support the WCRLF and the spatial extent of these habitats. A novel programmable camera system capable of collecting geo-referenced habitat information and water temperatures was developed and trialed as part of FRDC project 2011/021: *Development of an industry-based habitat mapping/monitoring system*.

Low per unit costs and a small, robust design allow widespread deployment of multiple camera units which have been attached to the WRL pots of commercial fishers. The automatic operation of the units and long deployment life (months) allows near continuous collection of habitat information with no added cost or interruption to fishing operations. Approximately 20 commercial fishers participated in the initial trial, providing geo-referenced videos of benthic habitats for over 1500 lobster pot deployments. The habitat information collected spans over 650km and ca 6 degrees of latitude (Figure 7.3).

As the project is ongoing, the information provided will document the types and distribution of key benthic habitats across the extent of the fishery. This spatially explicit information is now used to help inform/validate benthic species distribution models (see Section 5.2). A new prototype is currently being developed and will soon be distributed to participating fishers. The wide spatial coverage and continuous nature of the data acquisition means PotBOTs may be relevant for monitoring changes in habitats overtime.

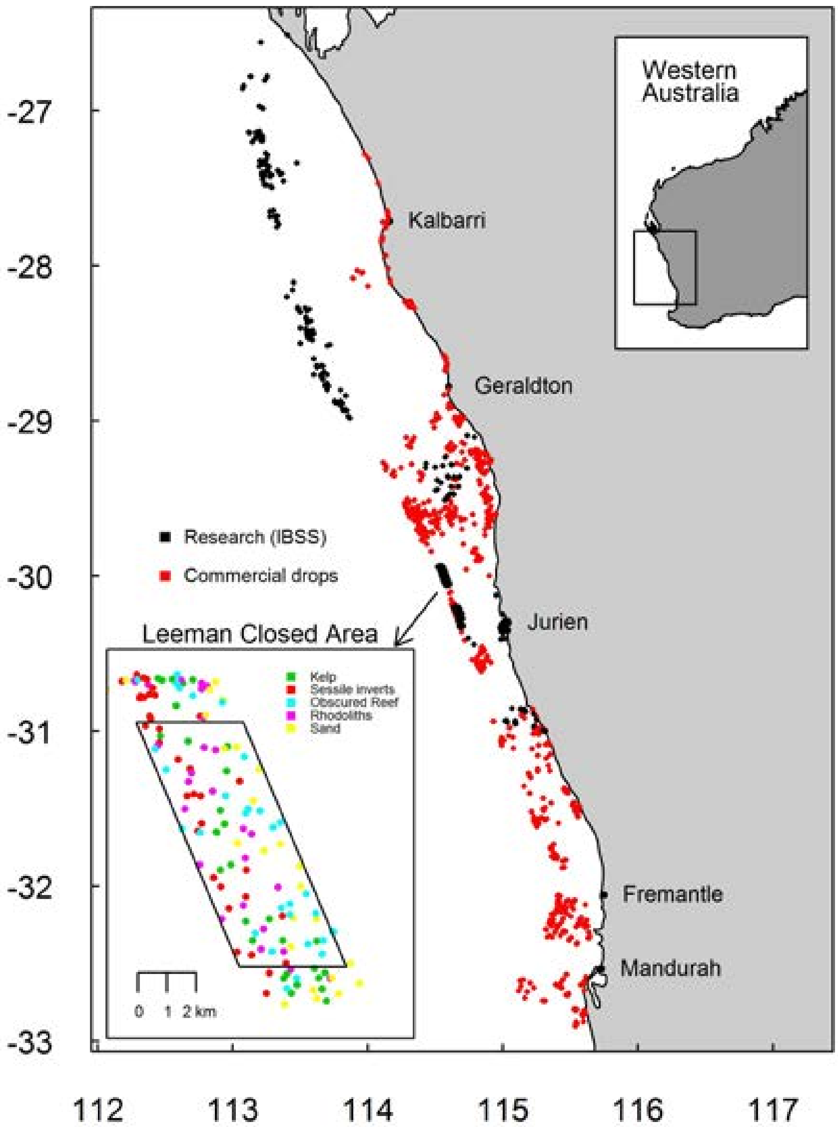

Figure 7.3 Spatial distribution of PotBOT deployments along the west coast of Western Australia. PotBOTs were attached to research pots (black) during the annual fishery independent breeding stock survey or deployed by commercial fishers during normal fishing operations (red). The inset illustrates the dominant benthic habitat observed in and around the Leeman closed area.

7.3 Broad scale WRL habitat association

Knowledge of the spatial arrangement and extent of habitats allows for a spatially explicit examination of fishing effort on key WRL habitats, particularly reef and reef with kelp (referred to as kelp). Catch disposal records (CDR) contain fishing data (e.g. fishing effort recorded as the number of pot lifts) collected by commercial WRL fishers and aggregated at a resolution of 10 arc minute blocks that cover the extent of the fishery (Figure 7.4a). These CDR blocks are overlayed on the habitat distribution map to show distribution of total effort (Figure 7.4b), total catch (Figure 7.4c) and catch rate (Figure 7.4d) data.

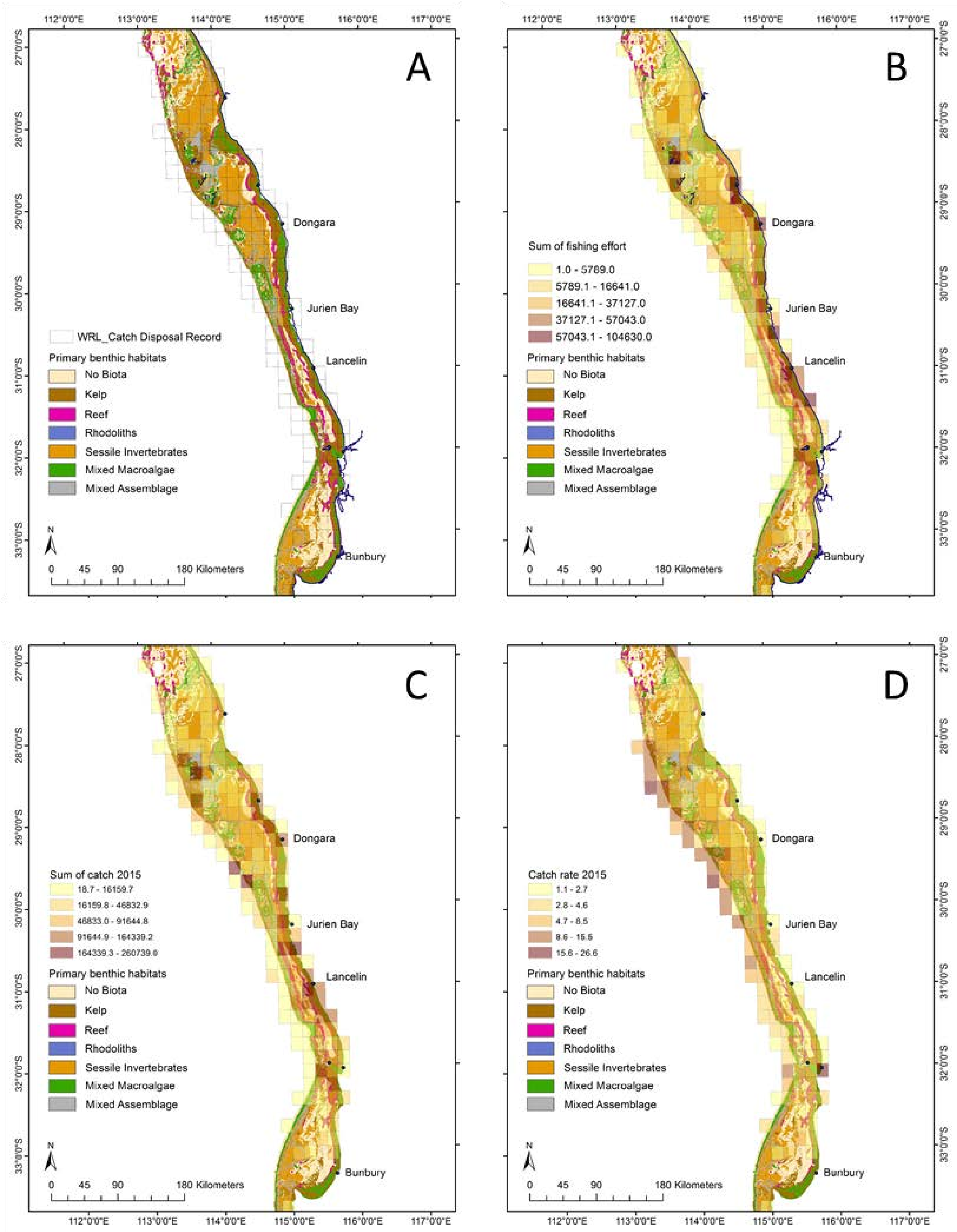

Figure 7.4 Distribution of key habitats overlayed with a) catch disposal record (CDR) blocks, b) sum of fishing effort (including both red and white lobster catches), c) sum of fishing catch and d) catch rate from 2015 over the extent of fishery.

A broad scale overview of WRL potting effort and habitat association for the 2015 season was achieved by extracting habitat information as a proportion for each individual CDR block. Reef, reef with kelp (kelp) and sessile invertebrates contribute to the greatest areal

coverage of primary habitat types within the extent of the fishery. Reef and kelp dominate nearshore habitats particularly in the southern most region of the fishery (Figure 7.5a), while sessile invertebrates tend to dominate in the northern regions (Figure 7.5b). In general, fishing effort is concentrated on areas with the highest proportions of reef and reef with kelp, with inshore reefs targeted more than offshore systems (Figure 7.5c). Total fishing catch shows similar patterns (Figure 7.5d), however, catch rate (number of WRL per pot lift) increases markedly as you move offshore (Figure 7.5e) and may be a result of lower fishing pressure offshore. A simple correlation analysis between percent reef and reef with kelp (kelp) habitat per block and total fishing effort across three years of data (2012-2014) supports this pattern (Figure 7.6). However, other factors such as distance to home port, target catch (red versus whites) and changes in management (e.g. changes to quota and the fishing season) will also influence the spatial variation in fishing effort.

Total effort, catch and catch rate (number of WRL caught per pot lift) per CDR block can be tracked over time to look for any significant changes habitat use from year to year (Figure 7.7, Figure 7.8 and Figure 7.9 respectively). Patterns in the spatial distribution of fishing effort appear to vary little between years (Figure 7.7). Total catch (Figure 7.8) and catch rate (Figure 7.9) also remain similar from 2013 to 2015. This suggests that inshore reef systems are the key targeted habitat for the WCRLF, particularly around Lancelin, Jurien and Geraldton.

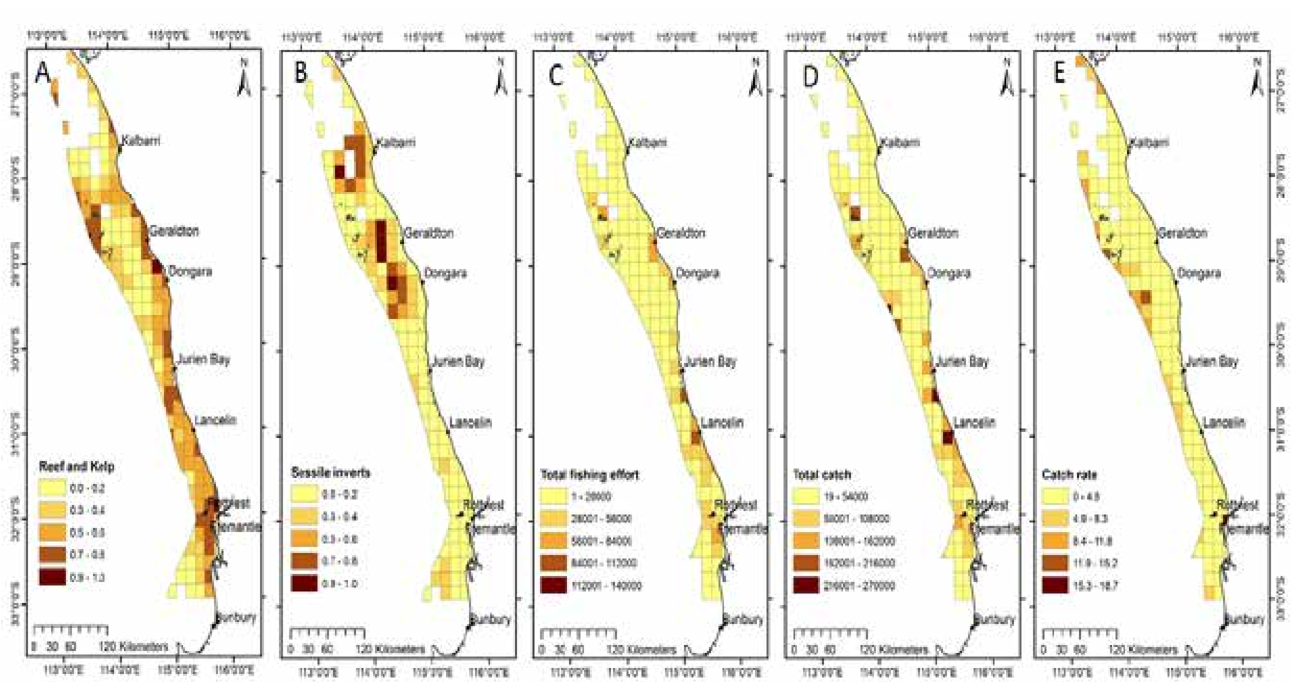

Figure 7.5 Spatial patterns in the proportion of a) reef and kelp habitat, b) sessile invertebrates, c) total fishing effort, d) total catch and e) catch rate per CDR block for 2015.

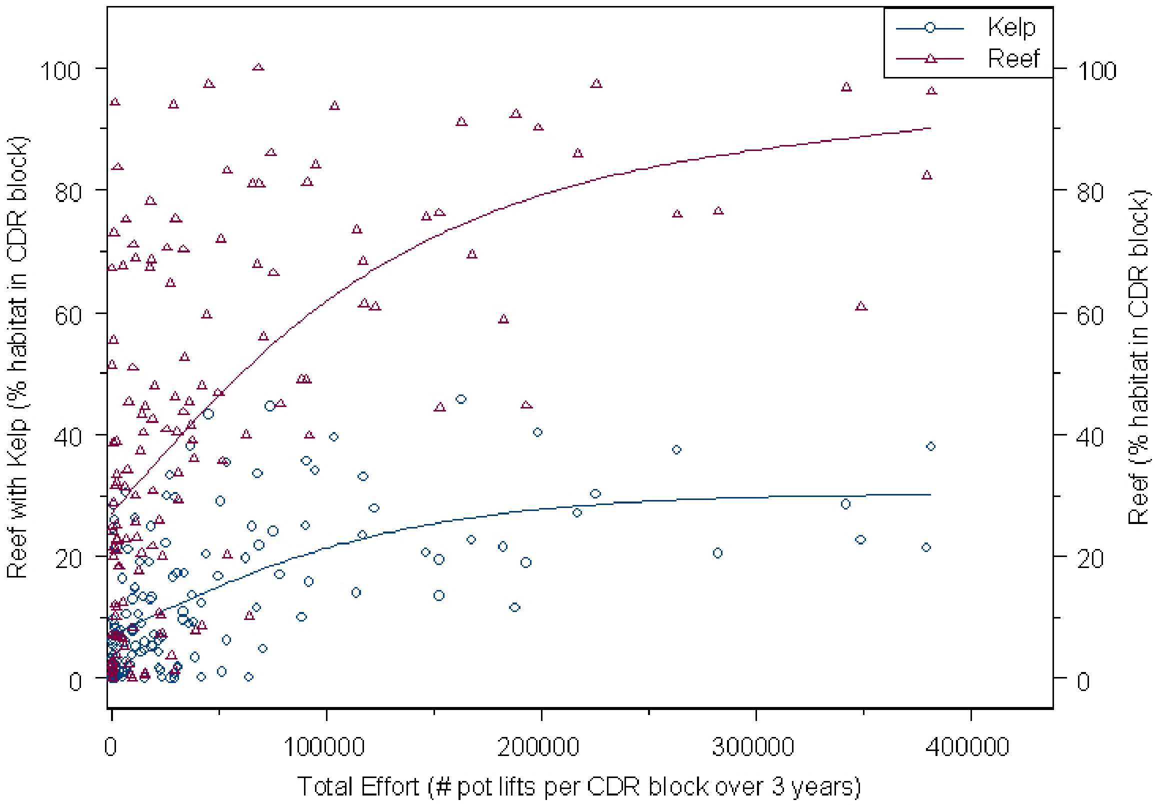

Figure 7.6 Relationship between fishing effort and percent kelp and reef habitat based on data extracted from CDR blocks.

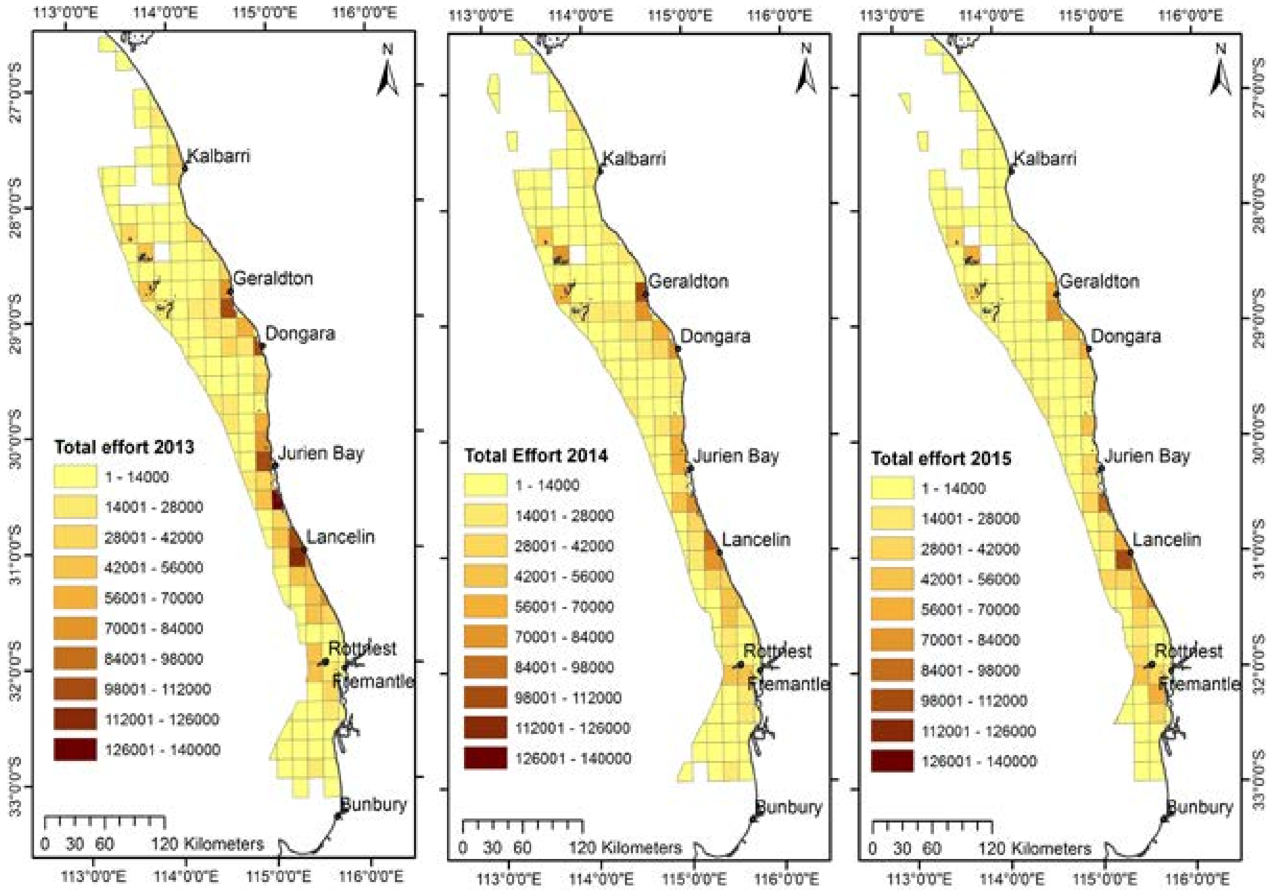

Figure 7.7 Spatial variation in total fishing effort between (left to right) 2013, 2014 and 2015.

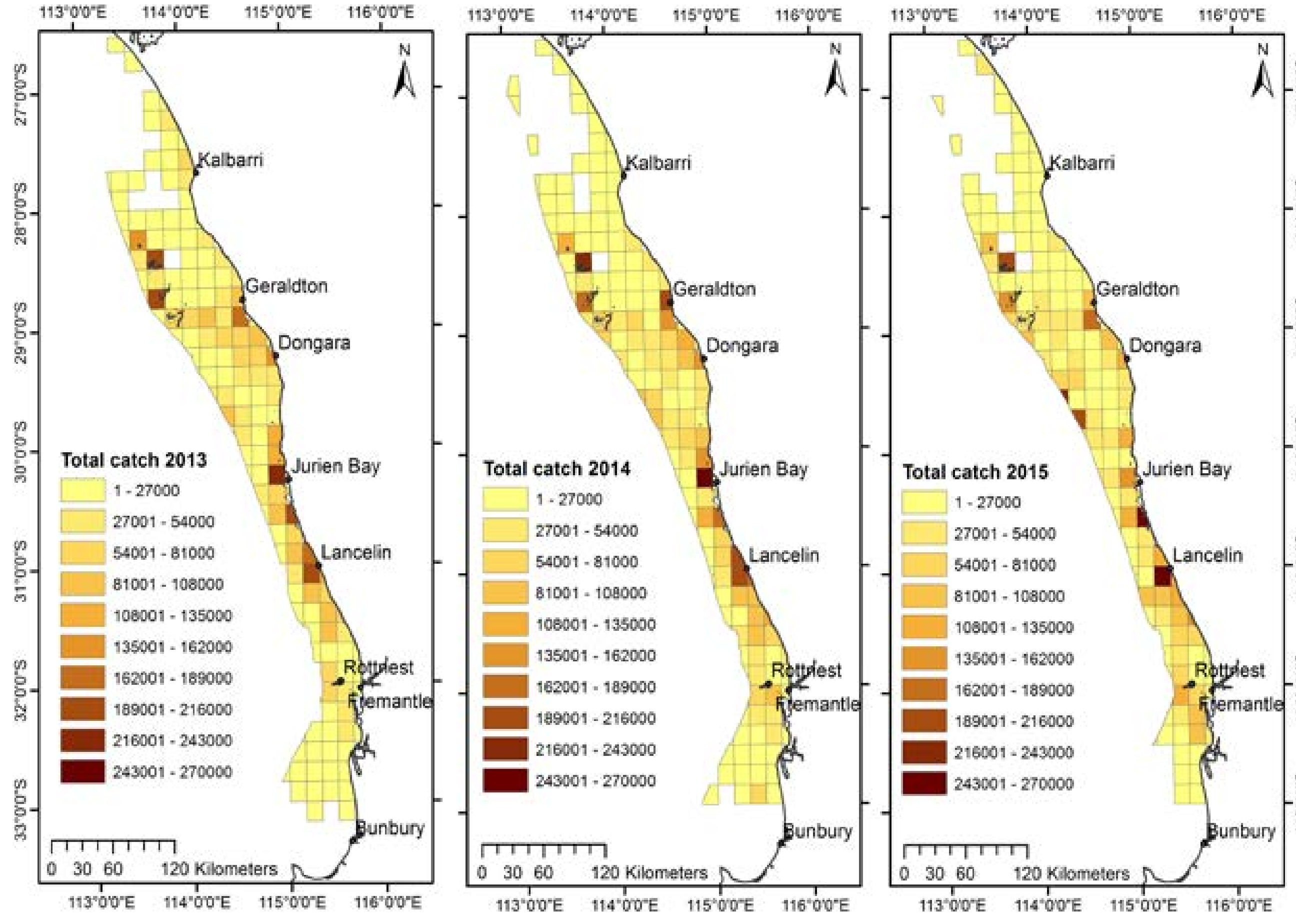

Figure 7.8 Spatial variation in total fishing catch between (left to right) 2013, 2014 and 2015.

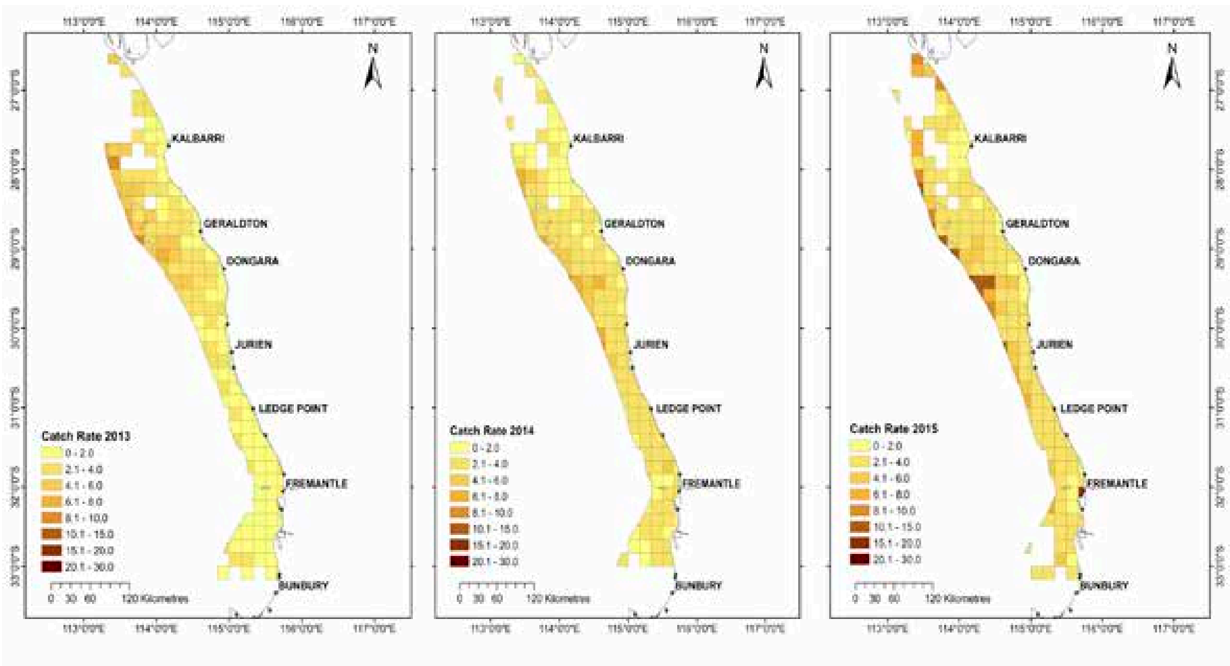

Figure 7.9 Spatial variation in catch rate between (left to right) 2013, 2014 and 2015.

7.3 Shallow-water research

7.3.1 Jurien Bay Marine Park

With the development of research projects on the effects of WRL biomass removal on the deep water (>40m) ecosystem off the coast of Jurien, comparative links to studies in the shallow water were suggested by the EcoSRG (Department of Fisheries 2006). Since 2008, annual research potting surveys to compare the size, sex and abundance of WRL in areas open and closed to fishing in the deep water off the Jurien coast have been conducted as part of the annual Independent Breeding Stock Survey (IBSS). These surveys have shown a substantial increases in WRL abundance, particularly large males, which can be attributed to the Leeman closure. With the lack of a similar data in areas open and closed to fishing in the shallow water (<10m), a potting survey using similar techniques to that of the IBSS was undertaken in the Jurien Bay Marine Park (JBMP) by the Department.

Declared in 2003, the JBMP covers an area of ~432 nm^2 along the Western Australian coast from Wedge Island in the south to Greenhead in the north and out to state territorial waters (three nautical miles) (Department of Conservation and Land Management 2005, Edgar and Barrett 2012). With six categories of management affording differing levels of protection, the JBMP is the nearest shallow water location to the Leeman closure (~17 nm) with management zones that afford WRL protection from fishing. Two of these categories, sanctuary and special purpose puerulus, are the only two that provide total protection from all WRL fishing. Within the JBMP there are 12 separate sanctuary or special purpose puerulus areas, the largest being 7.2 nm^2 and the smallest 0.002 nm^2 (mean size of 1.4 nm^2). The habitats of the JBMP are defined in (Hill 2005) to seven categories; intertidal reef (0.1%), macro algae (4.7%), seagrass (17%), sub tidal reef (24.8%) and sand (53.4%) The habitat classes are not uniform across the management zones, with the two management zones closed to lobster fishing dominated by sand (36.4%) and seagrass (44.0%).

This study of WRL abundance in the JBMP was undertaken in September 2014 in conjunction with the Jurien IBSS, using three of the 12 sanctuary (closed) zones in the JBMP (Boullanger Island, Fisherman Islands and North Head) and adjacent general use (open) zones (a minimum of 200m from the sanctuary zone border). Potting was scaled to the size of the sanctuary zone with effort targeted to the favoured WRL habitat of sub tidal reef and macro algae to maximise catch returns. An equal number of pots were also set in adjacent general use areas, with each sanctuary zone and adjacent general use area potted on a single occasion with a one day pull. A total of 62 commercial batten pots with closed escape gaps, sea lion exclusion devices and approximately 1 kg of blue mackerel per pot as bait were deployed; Boullanger Island (15 general use and 15 sanctuary), Fisherman Islands (10 general use and 10 sanctuary) and North Head (6 general use and 6 sanctuary).

A total of 279 WRL were recorded, with 87% of the catch (242 WRL) coming from areas

open to WRL fishing (general use) and 13% coming from the closed areas (sanctuary). The highest mean number of WRL per pot was observed in the Boullanger Island general use zone with 15.3 (±3.6) WRL per pot and the lowest in Fisherman Islands sanctuary zone with 1 (±0.4) WRL per pot (Figure 7.10). Overall the general use areas showed higher mean abundance of WRL than the sanctuary zones that they were immediately adjacent to. However, if the high abundances of the Boullanger general use zone were excluded, overall abundance between the fished and no fished areas are less pronounced (Figure 7.10).

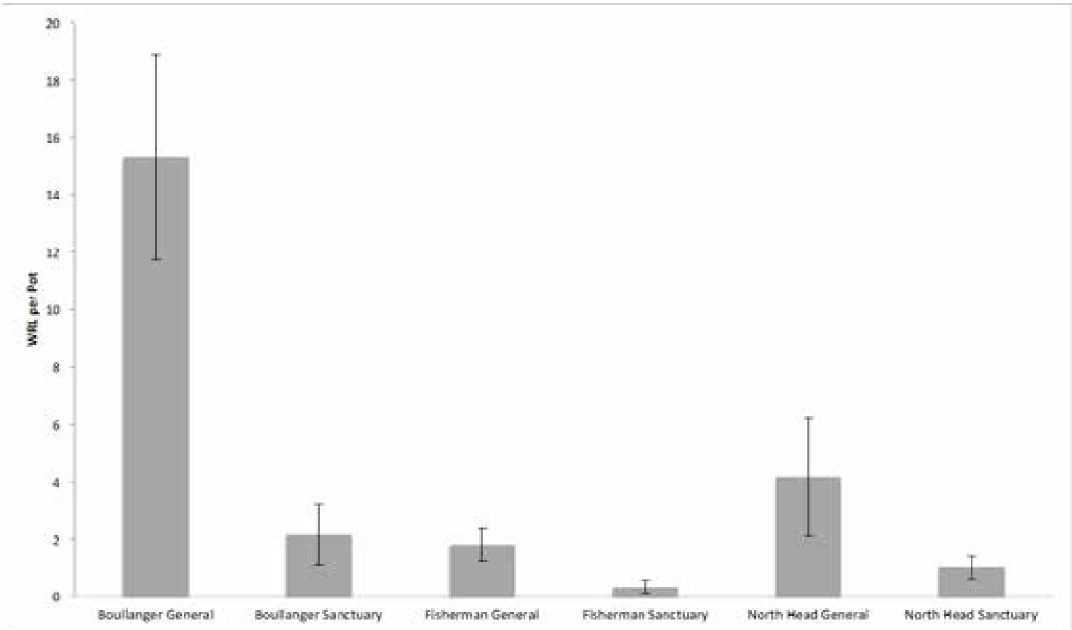

Figure 7.10 Mean catch rates of WRL in three sanctuary zones and adjacent general use areas in the JBMP.

To compare size and sex abundances between general use and sanctuary zones, the catch per unit of effort (CPUE) was calculated by pooling all catches from the two levels of management protection, e.g. sanctuary and general use (Figure 7.11). Similar to the trends observed in mean abundance the general use areas observed the highest CPUE for all WRL observed (Figure 7.11). The general use areas also recorded higher CPUE when comparing males and female WRL overall, under size (<76mm) and size (>=76mm) (Figure 7.11). This trend is the opposite to that observed in areas open and closed to WRL fishing the deep water (Figure 6.2 and Figure 6.3).

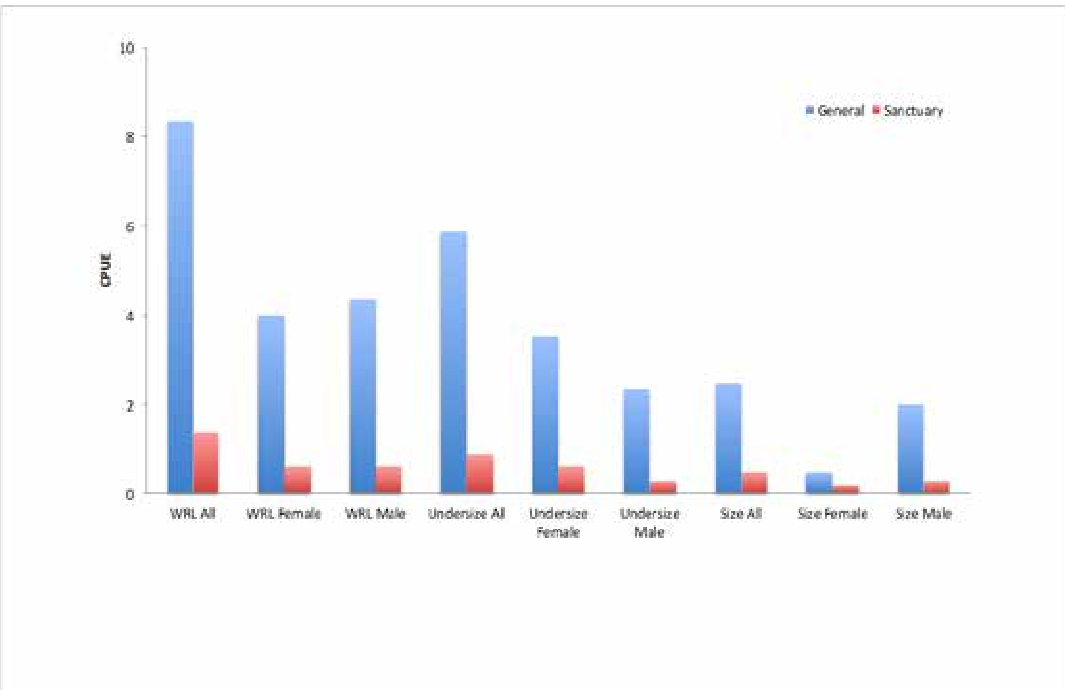

Figure 7.11 Catch per unit effort of WRL in general use and sanctuary zones of JBMP

The results from this survey suggest the sanctuary zones of the JBMP provide little benefit to the protection of WRL, regardless of size or sex when compared with both nearby shallow water general use zones and deep water area closures. This could be attributed to many factors including the study site, species life history and fisheries management. With respect to the study site, the sanctuary zones of JBMP are relatively small and likely not large enough to encapsulate the foraging range of WRL. With the low levels of suitable habitat within the sanctuary zones of the JBMP for WRL it is also probable that they forage to areas outside the protected areas where they may be captured by 'edge' fishing. In addition, the migration of this species to the deep water as they near size of sexual maturity is well documented (George 1958, Melville-Smith and Beale 2009, de Lestang 2014). It is also evident in this study, with substantially less 'size' WRL in the shallow water to that of undersize (Figure 7.11). Presently WRL are also protected from capture until reaching 76 mm, when they near sexual maturity and migrate to the deep water. Therefore the level of protection to undersized WRL which use the shallow water habitats are equal for both the general use and protected areas, yet the abundance in the general use area was five times that in the sanctuary.

7.3.2 Rottnest Island

Located 10 nm off the Perth coast, Rottnest Island contains four sanctuary zones (SZ), with two new SZ established in 2007 to complement the existing two SZ which, while increased in size, have been in place since 1986. Using a combination of approaches, it was expected that a more robust assessment of the population dynamics and effects of SZ on WRL would be possible.

Surveys of WRL were conducted annually at Rottnest Island from 2008 to 2012 and are continuing to be surveyed every two years using a variety of pot types and underwater visual census (UVC). Surveys using these techniques were conducted at two areas that contained SZ established in 2007 (Armstrong Bay and Parker Point; Figure 7.12) and an additional area in 2012 (Kingston Reef; Figure 7.12) containing a SZ which had been protected for almost 30 years. Three sites inside and three sites adjacent to the SZ in each area were surveyed annually.

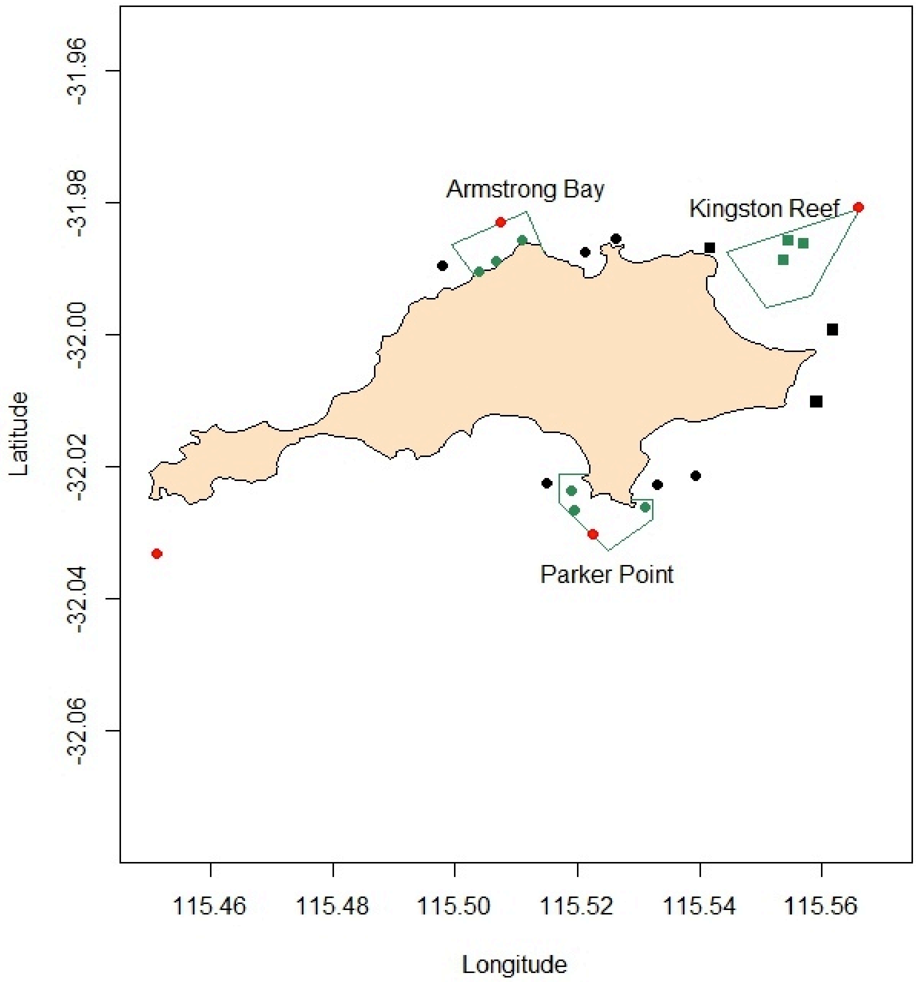

Figure 7.12 Locations of areas and associated sanctuary zones (green polygon) at Rottnest Island. Sites inside (green) and outside (black) the sanctuary zones at Armstrong Bay, Parker Point (filled circles) and Kingston Reef (squares). Temperature logger locations are also shown (red circles).

Three pot types were used; commercial, recreational and ‘mesh’, pots were pulled and set daily for three days at each site. Western rock lobster and by-catch were recorded, with full biological data recorded for all lobsters including size, sex, reproductive condition and appendage loss. All WRL were also tagged with T-bar tags before being released back at the site of capture.

UVC was conducted using both a timed and distance approach. Both approaches were conducted over ‘good WRL habitat’ which consisted of ledges and crevices within a limestone reef area. Timed searches consisted of three replicate 10 minute searches at each site, while distance surveys employed three replicate 30 x 2 metre transects at each site. During the UVC surveys WRL length was estimated and size composition of lobster dens noted. Where possible, WRL were captured using loops to provide biological data on the lobster and validate size estimates.

Sampling has produced detailed biological information on 1206 WRL and tagged 1003 WRL from 2008-2012. Western rock lobster sampled have ranged in size from 42 – 175 mm CL (carapace length). Estimates of movement from tag recaptures indicate that WRL are highly residential, with most recaptures occurring close to the release site. Biological data has shown that the size at maturity differ between sanctuary zones (Figure 7.13) which appears to be the result of different temperatures regimes at the different sanctuary zone.

Overall WRL catch rates (numbers/pot) did not differ between pot types, but the composition of the catch did. Commercial and recreational pots, both with closed escape gaps, had a similar catch composition, comprising mainly of legal sized WRL (Figure 7.14). However, the ‘mesh’ pot produced a significantly different size composition, containing a higher catch rate of smaller WRL (<70mm CL). Therefore, the use of a variety of pot types permitted a greater composition of the population to be captured.

UVC estimated the size of 450 WRL and captured 100 WRL from 54 dives conducted over the five years of sampling. Overall, estimated and actual carapace lengths were not significantly different (Figure 7.15) though there were significant differences between estimated and actual when examined by diver.

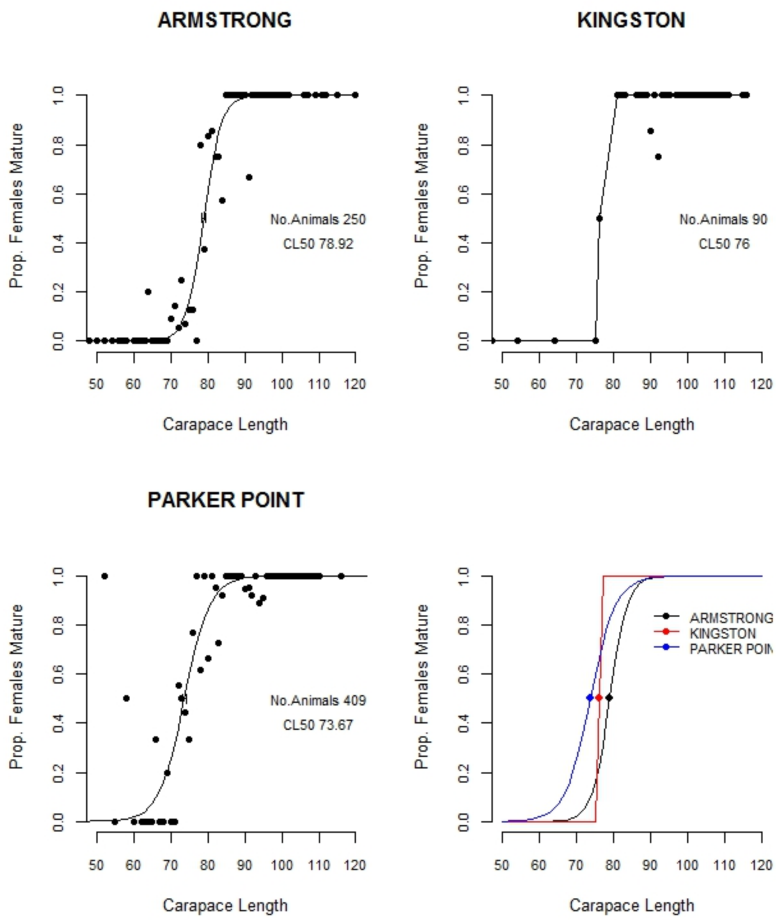

Figure 7.13 Logistic regressions of carapace length and maturity for female western rock lobsters captured at three sites around Rottnest Island

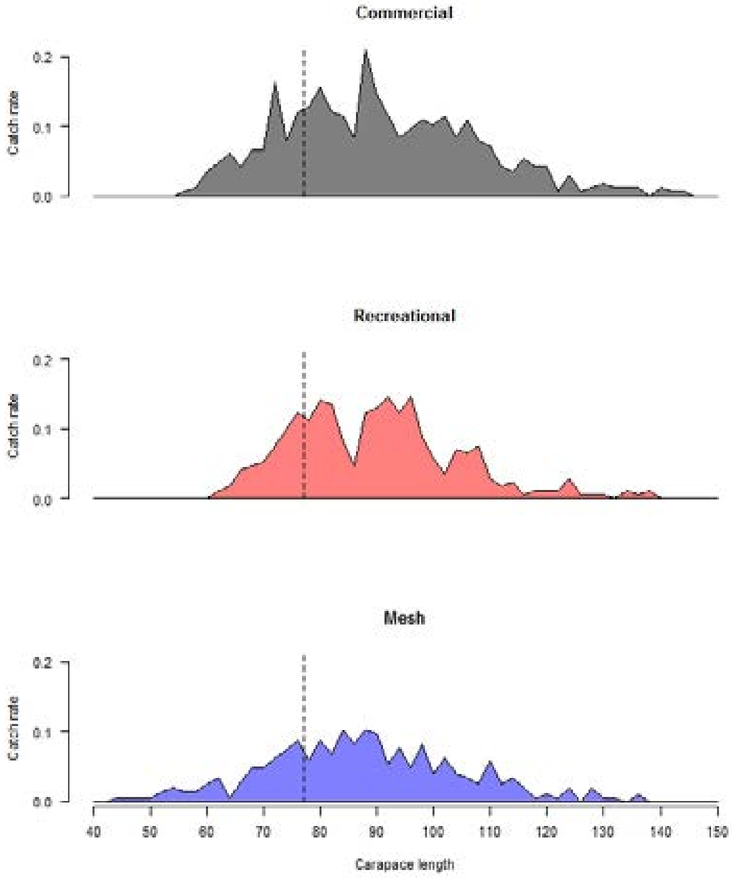

Figure 7.14 Size frequency of catches from different pot types surveyed at locations around Rottnest Island. Minimum legal size is indicated by dashed line.

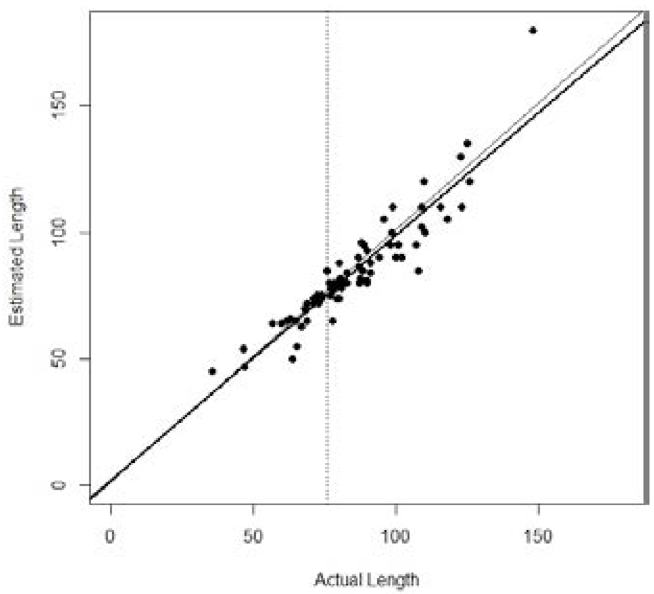

Figure 7.15 Overall evaluation of actual carapace length and estimated carapace length for western rock lobsters captured during underwater visual census. Heavy line represented the relationship between the actual and estimated size with the light line the 1:1 ratio. The dotted vertical line shows the legal minimum size (76 mm CL)

The gregarious nature of WRL highlighted the benefits of using a timed as opposed to a distance-based measure when assessing relative abundances through UVC. The heterogeneity of suitable habitat and/or the gregarious nature of WRL lends itself to a timed-based approach and provides a more repeatable and accurate assessment of WRL relative abundance as shown by the lower variation for the timed as opposed to distance measure. Data analysis is currently being finalised regarding these survey comparisons.

Results from potting showed that there was an increase in abundance in SZ compared to adjacent fished areas, though this wasn't always significantly different (Figure 7.16). High water temperatures associated with a heat wave which moved down the coast in early 2011 appears to have impacted negatively on pot catchability at all sites (Figure 7.16). A similar though less clear pattern is shown from UVC data inside and outside of the SZ at Rottnest Island, with generally more WRL surveyed inside the sanctuary zones than the adjacent fished sites (Figure 7.17). Due to the variation in the types of UVCs used (timed versus distance transects) further analysis is required to standardise these methods and assess the effect on size structure so these results should be treated as preliminary at this stage.

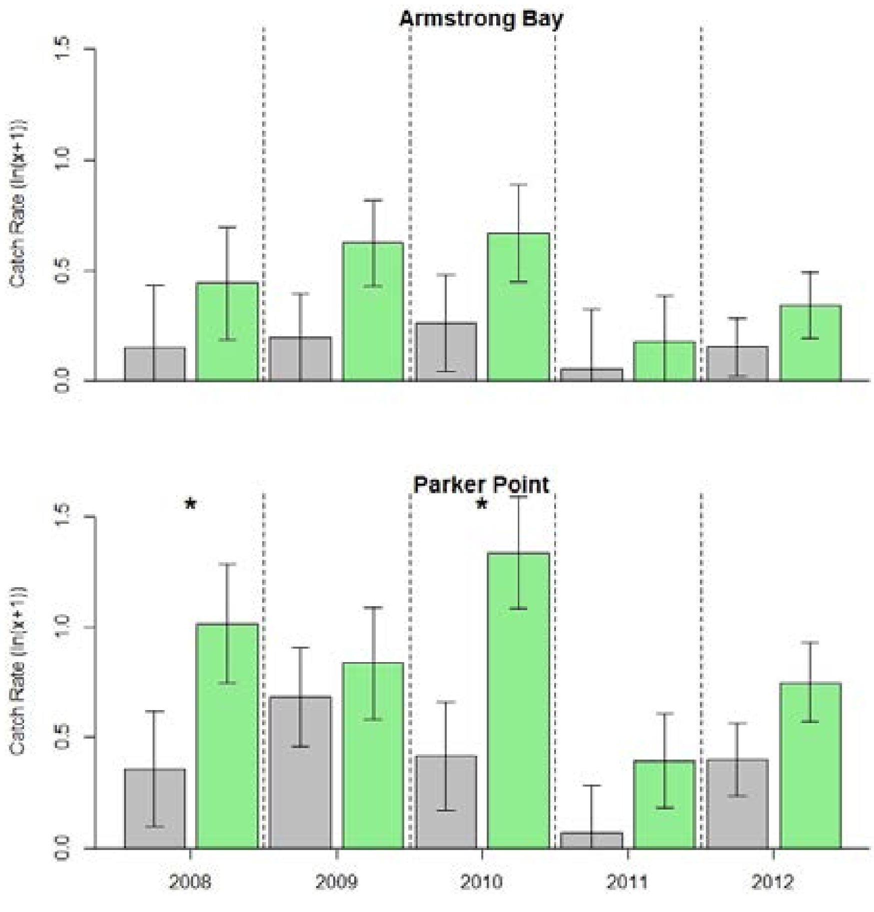

Figure 7.16 Annual mean catch rates (*ln (x+1)* transformed; ±SE) of legally retainable lobsters from potting surveys conducted inside (green) and outside (grey) sanctuary zones at Armstrong Bay and Parker Point. Asterisk indicates a significant difference in catch rates between inside and outside of the sanctuary zones for that year

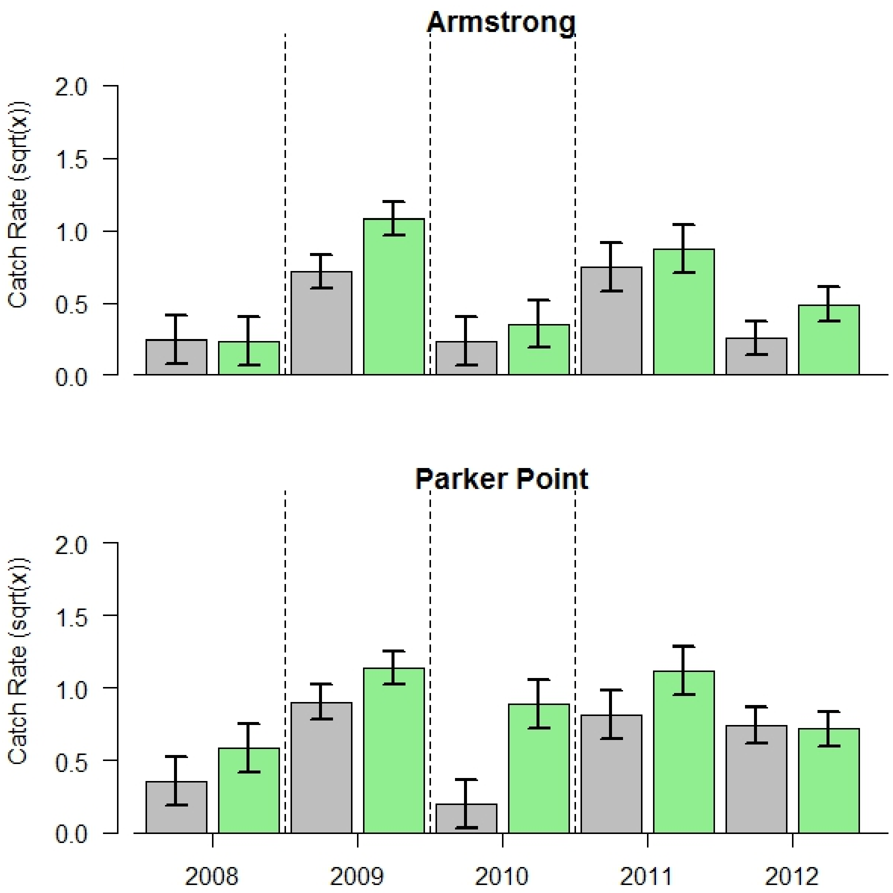

Figure 7.17 Annual mean catch rates (*ln (x+1)* transformed; ±SE) of legally retainable lobsters from diving surveys conducted inside (green) and outside (grey) sanctuary zones at Armstrong Bay and Parker Point.

The combination of potting and UVC sampling methods, including the use of appropriate pots or UVC survey types has provided a robust assessment of SZ performance, and population demographics. Future surveys of SZ, particularly for lobster species, should look to the incorporation several, independent methods to robustly assess the SZ performance but also the dynamics of the population.

7.4 Climate Change

Impact of climate change on the target stock is reported in de Lestang *et al*. (in press).

de Lestang *et al*. (2010a) initiated a project in response to the lower than expected puerulus settlement for the WRL on the Western Australian coast during 2008. The objectives were to monitor the community composition of marine flora and fauna along the Western Australian coastline, while developing standard methodology for assessing the spatial and temporal variability in their settlement. The aim was to determine what environmental factors may be linked to the majority of variation in the floral and faunal communities colonizing puerulus collectors, focusing on those relating to puerulus settlement, and to identify what species could be used as indicator species for monitoring climate change effects along the West

Australian coast.

The project was commenced during the 2008/09 and 2009/10 seasons and encompassed five sites covering over 1000 km of coastline from Coral Bay to Warnbro. Each site was monitored in both winter and spring seasons, with two sites monitored in all four seasons. Out of the total 157 740 individuals sampled, the Order *Amphipoda* encompassed almost half of all individuals and was three-times greater in abundance than the second most abundant taxa (Class *Gastropoda*), which were double that of *Isopoda*, *Tanaidacea* and *Ostracoda* (Class). There was significant spatial and seasonal variation in the composition of the communities, in particular between sites located in the tropics/sub-tropics and those located in temperate zones. This difference was thought to be due to the greater abundance of taxa in the temperate locations compared with the tropics.

Climate change parameters such as increased water temperature and salinity, as well as less frequent and severe storm events, significantly impacted on the abundance of a number of taxa found commonly on the collectors. Such relationships, along with the discovery of some individuals found outside of their normal distributional range, e.g. the tropical species *Strombus mutabilis*, indicate that the monitoring of a range of species on the puerulus collectors can provide an indication of the localised environment and the impact of climate change.

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