APPENDICES

APPENDIX 1
Fisheries Research Division staff publications 2013/14

Scientific Papers

Bentley, B.C., Harvey, E.S., Newman, S.J., Welch, D.J., Smith, A.K. and Kennington, W.J. (2013). Characterization of 13 polymorphic microsatellite loci for the dogtooth tuna *Gymnosarda unicolor*. *Conservation Genetics Resources* 5 (3): 693-695.

Cappo, M., Marriott, R.J. and Newman, S.J. (2013). James's rule and causes and consequences of a latitudinal cline in the demography of John's Snapper (*Lutjanus johnii*) in coastal waters of Australia. *Fishery Bulletin* 111 (4): 309-324.

Caputi, N., de Lestang, S., Hart, A., Kangas, M., Johnston, M., and Penn, J. (2014). Catch Predictions in stock assessment and management of invertebrate fisheries using pre-recruit abundance; case studies from Western Australia. *Reviews in Fisheries Science* 22 (1): 36-54. http://www.tandfonline.com/eprint/6mD9abfs4HH7fSZFjpPS/full

Close, P.G., Ryan, T.J, Morgan, D.M., Beatty, S.J. and Lawrence, C.S. (2014). First record of 'climbing' and 'jumping' by juvenile *Galaxias truttaceus* Valenciennes, 1846 (Galaxiidae) from south-western Australia. *Australian Journal of Zoology* 62(2): 175-179.

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

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

Evans-Illidge, E.A., Logan, M., Doyle, J., Fromont, J., Battershill, C.N., Ericson, G., Wolff, C.W., Muirhead, A., Kearns, P., Abdo, D.A., Kininmonth, S., and Llewellyn, L. (2013). Phylogeny drives large scale patterns in Australian marine bioactivity and provides a new chemical ecology rationale for future biodiscovery. *PLoS ONE* 8(9): e73800. DOI: 10.1371/journal.pone.0073800

Fletcher, W.J. & Bianchi, G. (2014). The FAO-EAF Toolbox: making the Ecosystem Approach accessible to all fisheries. *Ocean and Coastal Management.* 90: 20-26.

French, B., Potter, I.C., Hesp, S.A., Coulson, P.G. & Hall, N.G. (2014). Biology of the harlequin fish *Othos dentex* (Serranidae), with particular emphasis on sexual pattern and other reproductive characteristics. *Journal of Fish Biology* 84: 106-132. DOI: 10.1111/jfb.12258

Gardner, M.J., Cottingham, A., Hesp, S.A., Chaplin, J.A., Jenkins, G.I., Phillips, N.M. & Potter, I.C. (2013). Biological and genetic characteristics of restocked and wild *Acanthopagrus butcheri* (Sparidae) in a southwestern Australian estuary. *Reviews in Fisheries Science* 21(3-4): 441-453. DOI: 10.1080/10641262.2013.796804

Hardinge, J., Harvey, E.S., Saunders, B. and Newman, S.J. (2013). A little bait goes a long way: The influence of bait quantity on a temperate fish assemblage sampled using stereo-BRUVs. *Journal of Experimental Marine Biology and Ecology* 449: 250-260.

Hart, A.M., Strain, L.W.S. & Hesp, S.A. (2013). Stock enhancement in Greenlip abalone Part III: Bioeconomic evaluation. *Reviews in Fisheries Science* 21(3-4): 354-374. DOI: 10.1080/10641262.2013.812506

Hartill, B.W., Cryer, M., Lyle, J.M., Rees, E.B., Ryan, K.L., Steffe, A.S., Taylor, S.M., West, L., Wise, B.S. (2012). Scale- and context-dependent selection of recreational harvest estimation methods: The Australasian experience. *North American Journal of Fisheries Management* 32(1): 109-123. DOI: 10.1080/02755947.2012.661387

Horne, J.B., Momigliano, P., van Herwerden, L. and Newman, S.J. (2013). Murky waters: searching for structure in genetically depauperate blue threadfin populations of Western Australia. *Fisheries Research* 146: 1-6.

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

Ley-Cooper, K., Lestang, S., Phillips, B. F., & Lozano-Álvarez, E. (2014). An unfished area enhances a spiny lobster, *Panulirus argus*, fishery: implications for management and conservation within a Biosphere Reserve in the Mexican Caribbean. *Fisheries Management and Ecology*. DOI: 10.1111/fme.12072

Marriott, R.J., O'Neill, M.F., Newman, S.J., Skepper, C.L. (2014). Abundance indices for long-lived tropical snappers: estimating standardized catch rates from spatially and temporally coarse logbook data. *ICES Journal of Marine Science* 71: 618-627.

Matejusova, I., Bain, N., Colquhoun, D.J., Feil, E., McCarthy, U., McLennan, D., Snow, M., Verner-Jeffreys, D., Wallace, S.I., Weir, S.J., Hall, M. (2013). Multilocus variable-number tandem-repeat genotyping of *Renibacterium salmoninarum*, a bacterium causing bacterial kidney disease in salmonid fish. *BMC Microbiology* 13: 285-293.

McDonald, J.I., Wilkens, S. L., Stanley J.A. and Jeffs, A.G. (2014). Vessel generator noise as a settlement cue for marine biofouling species. Biofouling: *The Journal of Bioadhesion and Biofilm Research* 30 (6): 741-749. DOI: http://dx.doi.org/10.1080/08927014.2014.919630

Metcalf, S.J., Dambacher, J.M., Rogers, P., Loneragan, N. and Gaughan, D.J. (2014). Identifying key dynamics and ideal governance structures for successful ecological management. *Environmental Science and Policy* 37: 34-49.

Molony, B.W., Church, A.R. & Cabassi, T. (2014). Tag loss and movement of stocked yearling rainbow trout (*Oncorhynchus mykiss*) in southwestern Australia. *New Zealand Journal of Marine and Freshwater Research* 48 (1): 60-69.

O'Neill, M.F., Leigh, G.M., Wang, Y-G., Braccini, J.M. and Ives, M.C. (2014). Linking spatial stock dynamics and economics: evaluation of indicators and fishery management for the travelling eastern king prawn (*Melicertus plebejus*). *ICES Journal of Marine Science* DOI:10.1093/icesjms/fst218.

O'Shea, O., Braccini, J.M., McAuley, R., Speed, C. & M. Meekan. (2013). Growth of tropical dasyatid rays estimated using a multi-analytical approach. *PLoS ONE* DOI: 10.1371/journal.pone.0077194.

Parsons, M.J.G., Longbottom, S., Lewis, P., McCauley, R.D. and Fairclough, D.V. (2013). Sound production by the West Australian dhufish (*Glaucosoma hebraicum*). *The Journal of the Acoustical Society of America* 134 (4): 2701-2709.

Parsons, M., Longbottom, S., McCauley, R., Lewis, P. and Fairclough, D.V. (2014). In situ calls of the marine perciform *Glaucosoma herbraicum*. *Acoustics Australia* 42 (1): 31-35.

Ruppert, J.L.W., Travers, M.J., Smith, L.L., Fortin, M.J., Meekan, M.G. (2013). Caught in the middle: combined impacts of shark removal and coral loss on the fish communities of coral reefs. *Plos One* 8:1-9.

Thebaud, O., Ellis, N., Little, L.R., Doyen, L., Marriott, R.J. (2014). Viability trade-offs in the evaluation of strategies to manage recreational fishing in a marine park. *Ecological Indicators* 46: 59-69.

Trinnie, F.I., Walker, T.I., Jones, P.L., Laurenson, L.J. (2014). Asynchrony and regional differences in the reproductive cycle of the greenback stingaree *Urolophus viridis* from south-eastern Australia. *Environmental biology of fishes* DOI:10.1007/s10641-014-0273-4

Wakefield, C.B., Williams, A.J., Newman, S.J., Bunel, M., Dowling, C.E., Armstrong, C.A., & Langlois, T.J. (2014) Rapid and reliable discrimination for two cryptic Eteline snappers using otolith morphometry. *Fisheries Research*, 151: 100-106.

Book Contributions

Caputi, N., de Lestang, S., Frusher, S., & Wahle, R.A. (2013). The impact of climate change on exploited lobster stocks. In: *Lobsters: biology, management, aquaculture and fisheries.* 2nd edition. Oxford, John Wiley & Sons, pp. 84-112.

Christensen, J. and Jackson, G. (2014). Shark Bay Snapper: Science, Policy, and the Decline and Recovery of a Marine Recreational Fishery. In '*Historical Perspectives on Fisheries Exploitation in the Indo-Pacific*'. Christensen J. and Tull M. (eds) Springer Verlag, pp 251-269.

Cochrane, K., Bianchi, G., Fletcher, W., Fluharty, D., Mahon, R., O. Arve Misund (2013). Regulatory and Governance Frameworks. In: *The Sea Volume 16. Ecosystem Based Management.* Harvard University Press Chapter 4, pp 77-119.

Reports

Brown, J., Dowling, C., Hesp, A., Smith, K., & Molony, B. (2013). Status of nearshore finfish stocks in southwestern Western Australia. Part 3: Whiting (Sillaginidae). *Fisheries Research Report No. 248*. Department of Fisheries, Western Australia. 128 pp.

Caputi, N., Feng, M., de Lestang, S., Denham, A., Penn, J., Slawinski, D., Pearce, A., Weller, E., How, J. (2014). Identifying factors affecting the low western rock lobster puerulus settlement in recent years. *Fisheries Research Report No. 255*. Department of Fisheries, Western Australia. 155 pp.

Caputi, N., Jackson, G. and Pearce, A. (2014). The marine heat wave off Western Australia during the summer of 2010/11 – 2 years on. *Fisheries Research Report 250*. Department of Fisheries, Western Australia. 36 pp.

Courtney, A.J., O'Neill, M.F., Braccini, J.M., Leigh, G.M., Kienzle, M., Pascoe, S., Prosser, A. J., Wang, Y.G., Lloyd-Jones, L., Ives, M., Montgomery, S.S. & Landers, M. (2013). Biological and economic management strategy evaluations of the eastern king prawn fishery. *Final Report. FRDC Project 2008/019.* Queensland Department of Agriculture, Fisheries and Forestry. 247 pp.

Department of Fisheries, Western Australia (2013). Key findings of the 2013 West Coast Demersal Scalefish Resource Stock Assessment. *Fisheries Management Paper No. 262*. Department of Fisheries, Western Australia. 36 pp.

Fairclough, D.V., Molony, B.W., Crisafulli, B.M., Keay, I.S., Hesp, S.A. and Marriott, R.J. (2014). Status of demersal finfish stocks on the west coast of Australia. *Fisheries Research Report No. 253*. Department of Fisheries, Western Australia. 92 pp.

Harvey, E.S., McLean, D.L., Frusher, S., Haywood, M.D.D., Newman, S.J. and Williams, A. (2013). The use of BRUVs as a tool for assessing marine fisheries and ecosystems: a review of the hurdles and potential. *Final Report to the Fisheries Research and Development Corporation, Project 2010/002*. The University of Western Australia, Perth, Australia. 202 pp.

Muñoz, J. (2014). Early Warning System for the Monitoring of Introduced Marine Pests Fremantle Port 2013-14 Report. *Department of Fisheries*. Report prepared for Fremantle Port Authority. 25 pp.

Muñoz, J. (2014). Early Warning System for the Monitoring of Introduced Marine Pests Port Hedland Port 2013 Report. *Department of Fisheries*. Report prepared for Port Hedland Port Authority. 19 pp.

Muñoz, J. (2014). Early Warning System for the Monitoring of Introduced Marine Pests Dampier Port 2013 Report. *Department of Fisheries*. Report prepared for Dampier Port Authority. 24 pp.

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

Palha de Sousa, L., Abdula, S., Palha de Sousa, B. and Penn, J. (2013). O Camarão do Banco de Sofala 2013. Relatório Interno de Investigação Pesqueira No. 18. Maputo, Mozambique Agosto 2013. 106 pp. (Assessment of the shallow water shrimp fishery of Sofala Bank, Mozambique 2012.) 106 pp.

Parsons, M.J.G., Fairclough, D. and McCauley, R.D. (2013). Passive acoustic techniques to monitor aggregations of sound producing fish species. *Final Report to Fisheries Research and Development Corporation, Project No. 2010/004*. Centre for Marine Science and Technology, Curtin University, Perth. 163 pp.

Ryan, K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H., Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. *Fisheries Research Report No. 249.* Department of Fisheries, Western Australia. 168 pp.

Smallwood, C. B., and Gaughan, D. J., (2013). Aerial surveys of shore-based recreational fishing in Carnarvon and Shark Bay: June to August 2012. *Fisheries Research Report No. 243*. Department of Fisheries, Western Australia. 44 pp.

Smallwood, C.B., Hesp, S.A., Beckley, L.E. (2013). Biology, stock status and management summaries for selected fish species in south-western Australia. *Fisheries Research Report No. 242*.Department of Fisheries, Western Australia. 180 pp.

Wakefield, C.B., Blight, S., Dorman, S.R., Denham, A., Newman, S.J., Wakeford, J., Molony, B.W., Thomson, A.W., Syers, C., & O'Donoghue, S. (2014) Independent observations of catches and subsurface mitigation efficiencies of modified trawl nets for endangered, threatened and protected megafauna bycatch in the Pilbara Fish Trawl Fishery. *Fisheries Research Report No. 244*. Department of Fisheries, Western Australia. 40 pp.

Wise, B.S., Fletcher, W.J. (2013). Determination and Development of Cost Effective Techniques to Monitor Recreational Catch and Effort in Western Australian Demersal Finfish Fisheries: Final Report for FRDC Project 2005/034 and WAMSI Subproject 4.4.3 *Fisheries Research Report No. 245*. Department of Fisheries, Western Australia. 162 pp.

Conference/Workshop Papers

Kolkovski, S., King, J., Watts, N., Natale, M., Bannister, J. and Stephens, F. (2013). Associated effects of bacteria on *Octopus tetricus* larvae rearing. *LARVI'13 – Fish and Shelfish larviculture Symposium*. Ghent, Belgium 2-5 September, 2013. pp. 211-214.

Kolkovski, S. and Kolkovski, J. (2013). Development of maturation diet for Penaeid shrimp using herbal extracts. *LARVI'13 – Fish and Shelfish larviculture Symposium*. Ghent, Belgium 2-5 September, 2013. pp. 208-211.

Kolkovski, S., King, B., Curnow, J., King, J., Natale, M. and Watts, N. (2014). The western australian artemia project – from concept to commercial reality. *World Aquaculture Society Symposium.* Adelaide, Australia, 7-11 June, 2014. pp. 333-334.

Watts, N., Kolkovski, S., King, J. and Natale, M. (2014). Current status of *octopus tetricus* paralarvae rearing. *World Aquaculture Society Symposium.* Adelaide, Australia, 7-11 June, 2014. pp. 763-764.

Natale, M., King, J., Watts, N. and Kolkovski, S. Octopus aquaculture – advancements in protocols and systems for ranching of *octopus tetricus*. *World Aquaculture Society Symposium.* Adelaide, Australia, 7-11 June, 2014. pp 505-506

Popular article

Caputi, N., Wahle, R., Moore, J. (2014). (Ed.) The Lobster Newsletter. 27(1). Department of Fisheries, Western Australia. 21 pp. http://www.fish.wa.gov.au/Species/Rock-Lobster/Pages/The-Lobster-Newsletter.aspx

Fairclough, D., Crisafulli, B., Lek, E., Allen, R. and Clayton, K. (2014). Monitoring the West Coast Demersal Scalefish Resource. *Newsletter No. 3, June 2014*. Department of Fisheries, Western Australia. 4 pp.

APPENDIX 2
Table of catches from fishers' statutory monthly returns for 2012/13

This table contains the landed[1] and estimated live weight[2] of species recorded in the compulsory catch and fishing effort returns provided by commercial fishers each month. These data include the catch taken as by-product as well as the targeted catch.

These catch data may differ slightly from some of the catch estimates presented for specific fisheries as the latter may include additional data from other sources, such as research log books and processors. The figures may also differ slightly from previously reported figures, as additional data may have been received by the Department of Fisheries. The table represents the latest year for which a complete set of data is available.

While scientific names have been included wherever possible, it should be noted that many fish recorded under a common name cannot be identified as belonging to a particular single species and therefore must be reported as being part of a commercial grouping of several species. For example, the common name 'Redfish' may be used for several species of the genus *Centroberyx*.

Data for species with live weight catches of less than 500 kg have been combined into the general or 'other' category within each class. Data for the Indian Ocean Territories Fishery have not been included in this table.

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH				
Carcharhinidae				
	Bronze Whaler	*Carcharhinus brachyurus*	30	48
	Dusky Whaler	*Carcharhinus obscurus*	92	147
	Sandbar Shark	*Carcharhinus plumbeus*	29	47
	Spinner Shark	*Carcharhinus brevipinna*	44	69
	Tiger Shark	*Galeocerdo cuvier*	3	4
Lamnidae				
	Shortfin Mako	*Isurus oxyrinchus*	2	3
Orectolobidae				
	Wobbegong Shark	Orectolobidae	18	28
Pristiophoridae				
	Common Sawshark	*Pristiphorus cirratus*	3	8
Rajidae				
	Skates	Rajidae	6	14
Sphyrnidae				
	Hammerhead Shark	Sphyrnidae	39	62
Triakidae				
	Gummy Shark	*Mustelus antarcticus*	253	403
	Pencil Shark	*Hypogaleus hyugaensis*	< 500 kg	1
	Whiskery Shark	*Furgaleus macki*	73	109

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Triakidae (Continued)				
	Shark, Other	*Chondrichthyes*	6	10
	Shovelnose/Fiddler Rays	Rhinobatidae / Rhynchobatidae	< 500 kg	1
Ariidae				
	Catfishes	Ariidae	11	11
	Silver Cobbler	*Neoarius midgleyi*	70	100
Berycidae				
	Bight Redfish	*Centroberyx gerrardi*	38	39
	Redfish	*Centroberyx* spp.	12	12
	Yelloweye Redfish	*Centroberyx australis*	11	11
Clupeidae				
	Australian Sardine (Pilchard)	*Sardinops sagax*	2221	2221
	Perth Herring	*Nematalosa vlaminghi*	1	1
	Sandy Sprat (Whitebait)	*Hyperlophus vittatus*	13	13
Hemiramphidae				
	Southern Garfish	*Hyporhamphus melanochir*	9	9
Platycephalidae				
	Flatheads	Platycephalidae	5	5
Plotosidae				
	Cobbler	*Cnidoglanis macrocephalus*	39	55
Haemulidae				
	Barcheek Coral Trout	*Plectropomus maculatus*	16	16
	Common Coral Trout	*Plectropomus leopardus*	2	2
Latidae				
	Barramundi	*Lates calcarifer*	28	46
Polyprionidae				
	Bass Groper	*Polyprion americanus*	1	1
	Hapuku	*Polyprion oxygeneios*	22	22
Serranidae				
	Birdwire Rockcod	*Epinephelus merra*	2	2
	Blackspotted Rockcod	*Epinephelus malabaricus*	26	26
	Breaksea Cod	*Epinephelides armatus*	6	6

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Serranidae (Continued)				
	Chinaman Rockcod	*Epinephelus rivulatus*	2	2
	Duskytail Grouper	*Epinephelus bleekeri*	6	6
	Eightbar Grouper	*Hyporthodus octofasciatus*	21	21
	Flowery Rockcod	*Epinephelus fuscoguttatus*	48	48
	Goldspotted Rockcod	*Epinephelus coioides*	49	49
	Rankin Cod	*Epinephelus multinotatus*	145	145
	Tomato Rockcod	*Cephalopholis sonnerati*	1	1
	Cods	*Epinephelus/Cephalopholis*	77	77
Glaucosomatidae				
	Northern Pearl Perch	*Glaucosoma buergeri*	26	26
	West Australian Dhufish	*Glaucosoma hebraicum*	80	81
Priacanthidae	Bigeyes	Priacanthidae	26	26
Terapontidae	Trumpeters	Terapontidae	3	3
Sillaginidae	King George Whiting	*Sillaginodes punctatus*	13	13
	Yellowfin Whiting	*Sillago schomburgkii*	62	62
	Whitings	Sillaginidae	107	107
Pomatomidae				
	Tailor	*Pomatomus saltatrix*	29	29
Rachycentridae				
	Cobia	*Rachycentron canadum*	14	14
Carangidae				
	Amberjack	*Seriola dumerili*	10	10
	Black Pomfret	*Parastromateus niger*	2	2
	Golden Trevally	*Gnathanodon speciosus*	4	4
	Samson Fish	*Seriola hippos*	37	40
	Silver Trevally	*Pseudocaranx* spp.	7	7
	Trevallies	Carangidae	142	142
	Yellowtail Kingfish	*Seriola lalandi*	1	1
	Yellowtail Scad	*Trachurus novaezelandiae*	19	19
Arripidae				
	Australian Herring	*Arripis georgianus*	288	288

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Arripidae (Continued)				
	Western Australian Salmon	*Arripis truttaceus*	236	236
Lutjanidae				
	Brownstripe Snapper	*Lutjanus vitta*	87	87
	Chinaman Fish	*Symphorus nematophorus*	12	12
	Crimson Snapper	*Lutjanus erythropterus*	255	255
	Darktail Snapper	*Lutjanus lemniscatus*	20	20
	Five Line Snapper	*Lutjanus quinquelineatus*	4	4
	Flagfish / Spanish Flag	*Lutjanus vitta / quinquelineatus / carponotatus / lutjan*	23	23
	Goldband Snapper	*Pristipomoides multidens*	729	730
	Jobfish	*Pristipomoides* spp.	1	1
	Mangrove Jack	*Lutjanus argentimaculatus*	14	14
	Moses Snapper	*Lutjanus russelli*	44	44
	Red Emperor	*Lutjanus sebae*	266	266
	Rosy Snapper	*Pristipomoides filamentosus*	6	6
	Ruby Snapper	*Etelis carbunculus*	22	23
	Saddletail Snapper	*Lutjanus malabaricus*	180	180
	Sharptooth Snapper	*Pristipomoides typus*	3	3
	Tropical Snappers	Lutjanidae	2	2
Nemipteridae				
	Monocle Bream	*Scolopsis* spp.	11	11
	Threadfin Breams	Nemipteridae	101	101
Haemulidae				
	Javelin Fish	*Pomadasys* spp.	18	18
	Painted Sweetlips	*Diagramma labiosum*	20	20
	Sand Snapper	Haemulidae	50	50
Lethrinidae				
	Bluespotted Emperor	*Lethrinus punctulatus*	236	236
	Drab Emperor	*Lethrinus ravus*	5	5
	Grass Emperor	*Lethrinus laticaudis*	6	6
	Longnose Emperor	*Lethrinus olivaceus*	23	23
	Mozambique Seabream	*Wattsia mossambica*	5	5

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Lethrinidae (Continued)				
	Redspot Emperor	*Lethrinus lentjan*	24	24
	Redthroat Emperor	*Lethrinus miniatus*	46	46
	Robinson'S Seabream	*Gymnocranius grandoculis*	41	41
	Spangled Emperor	*Lethrinus nebulosus*	70	70
	Emperors	Lethrinidae	2	2
Sparidae				
	Black Bream	*Acanthopagrus butcheri*	44	44
	Frypan Bream	*Argyrops spinifer*	35	35
	Snapper (Pink Snapper)	*Pagrus auratus*	475	478
	Tarwhine	*Rhabdosargus sarba*	4	4
	Western Yellowfin Bream	*Acanthopagrus latus*	8	8
	Yellowback Bream	*Dentex tumifrons*	1	1
Sciaenidae				
	Black Jewfish	*Protonibea diacanthus*	2	2
	Mulloway	*Argyrosomus japonicus*	13	14
Mullidae				
	Red Mullet	Mullidae	36	36
Clupeidae				
	Scaly Mackerel	*Sardinella lemuru*	364	364
Kyphosidae				
	Sweep	*Scorpis aequipinnis*	1	1
Pentacerotidae				
	Boarfish	Pentacerotidae	6	7
Oplegnathidae				
	Knifejaw	*Oplegnathus woodwardi*	1	1
Cheilodactylidae				
	Blue Morwong	*Nemadactylus valenciennesi*	35	38
	Morwong	Cheilodactylidae	1	1
Mugilidae				
	Mullets	Mugilidae	6	6

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Mugilidae (Continued)				
	Sea Mullet	*Mugil cephalus*	154	154
	Yellow-Eye Mullet	*Aldrichetta forsteri*	26	26
Sphyraenidae				
	Pikes	Sphyraenidae	4	4
	Snook	*Sphyraena novaehollandiae*	2	2
Polynemidae				
	King Threadfin	*Polydactulus macrochir*	38	44
	Threadfin	Polynemidae	2	2
Labridae				
	Baldchin Groper	*Choerodon rubescens*	16	16
	Blue Groper	*Achoerodus gouldii*	29	35
	Bluespotted Tuskfish	*Choerodon cauteroma*	2	2
	Pigfish	*Bodianus* spp.	1	1
	Tuskfishes	*Choerodon* spp.	6	6
	Wrasses	Labridae	1	1
Scaridae				
	Parrotfishes	Scaridae	5	5
Acanthuridae/Zanclidae				
	Surgeonfishes	Acanthuridae/Zanclidae	2	2
Scombridae				
	Bonito	*Sarda australis*	22	22
	Grey Mackerel	*Scomberomorus semifasciatus*	16	16
	Spanish Mackerel (Narrow-barred)	*Scomberomorus commerson*	226	309
	Longtail Tuna	*Thunnus tonggol*	1	1
	Yellowfin Tuna	*Thunnus albacares*	1	1
	Mackerel, Other		< 500 kg	< 500 kg
	Tuna, Other		2	2
Centrolophidae				
	Blue-Eye Trevalla	*Hyperoglyphe antarctica*	3	3
Bothidae				
	Flounder	Bothidae	2	3

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Monacanthidae				
	Leather Jacket	Monacanthidae	14	21
	Fish, other		96	99
TOTAL FISH			8615	9156
CRABS				
	Crystal Crab	*Chaceon albus*	141	141
	Champagne Crab	*Hypothalassia acerba*	4	4
	Giant Crab	*Pseudocarcinus gigas*	15	15
	Blue swimmer Crab	*Portunus armatus*	274	277
	Mud Crab	*Scylla* spp.	4	4
TOTAL CRABS			438	441
PRAWNS				
	Banana Prawn	*Penaeus merguiensis*	324	324
	Brown Tiger Prawn	*Penaeus esculentus*	631	631
	Coral Prawn	*Metapenaeopsis* spp.	137	137
	Endeavour Prawn	*Metapenaeus endeavouri*	62	62
	Western King Prawn	*Penaeus latisulcatus*	1165	1165
	Prawns, Other	Penaeidae	1	1
TOTAL PRAWNS			2320	2320
LOBSTERS				
	Southern Rock Lobster	*Jasus edwardsii*	46	46
	Western Rock Lobster	*Panulirus cygnus*	6020	6020
	Bugs/ Slipper lobster	Scyllaridae	4	4
TOTAL LOBSTERS			6070	6070
MOLLUSCS				
	Squid	*Sepioteuthis* spp./*Loligo* spp.	37	37
	Octopus	Octopodidae	196	250

Family Name	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
MOLLUSCS (Continued)				
	Cuttlefish	Sepiidae	32	32
	Saucer scallop	*Amusium balloti*	58	292
	Brownlip Abalone	*Haliotis conicopora*	15	37
	Greenlip Abalone	*Haliotis laevigata*	57	152
	Roe's Abalone	*Haliotis roei*	70	70
TOTAL MOLLUSCS			465	870
OTHER INVERTEBRATES			4	13
GRAND TOTAL			17912	18870

1. *Landed weight*: refers to the mass (or weight) of a product at the time of landing, regardless of the state in which it is landed. That is, the fish may be whole, gutted or filleted etc. This unit is of limited use for further analysis except where it is known that the product is very homogenous in nature. Where more detailed analysis of the data is required the landed weight is generally converted to a more meaningful measure, the most frequently used being termed live or whole weight or 'nominal catch'.
2. *Live weight*: refers to the landings converted to a live weight basis. This is often referred to as the 'live weight equivalent of the landings', shortened to the 'live weight'. Although live weight may be the preferred unit it is rarely obtained as a direct measure. This is because it would usually have to be made on board a fishing vessel where the practical difficulties associated with the working conditions render it impossible. Live weight has to be derived and this is usually done by applying a conversion factor to the landed weight.
3. Weight figures are round off to the nearest tonnage.
4. Common names are from the CAAB – Codes for Australian Biota database.

More information may be obtained from the 'CWP Handbook of Fishery Statistical Standards' at the website http://www.fao.org/fishery/cwp/handbook/B/en

Estimated Western Australian Aquaculture Production for 2012/13

K. Nobes

Main Features

There were 453 licensed aquaculture producers

The farm gate value of aquaculture production in WA (excluding marine algae and pearl oysters) was just over $16.78 million

The most valuable industry sector was barramundi ($12.5 million), followed by marron ($1.50 million), mussels ($1.02 million) and yabbies ($0.42 million)

The industry sector with the most participants was marron with 175 productive licences.

Introduction

The statistics contained in this document represent the reported production and estimated value of the aquaculture industry in Western Australia for the financial year 2012/13. Comparisons to the previous four years have also been presented. The following summaries were produced from information held within the Aquaculture Production Returns Database at the Department of Fisheries, Research Division, Hillarys.

Quarterly records received from industry are summarised by the Department of Fisheries. Producers' returns constitute the official production and value figures for the aquaculture industry and these are dependent on the accuracy of licensees' returns. The data presented are based on the Aquaculture Production Returns Database, as of May 2014.

The Industry in 2012/13

A total of 453 aquaculture licence holders were required to submit quarterly returns for one or more quarters in the 2012/13 financial year. Of the 453 licences, 214 i.e. 47 per cent recorded production on their returns. Marron had the largest number of producers with 175 licences recording production (Aquaculture Production Table 1).

Estimated aquaculture production decreased from 1661 tonnes produced in 2011/12 to 1566 tonnes in 2012/13 (excludes algae, pearl oysters, and ornamental species) (Aquaculture Production Table 2).

The estimated value of Western Australian aquaculture (excluding algae and pearl oysters) increased from $16.2 million to $16.8 million in 2012/13 (Table 3). Finfish aquaculture made up 76 per cent of the total value for 2012/13.

AQUACULTURE PRODUCTION TABLE 1

Growout production for the Western Australian aquaculture industry in 2012/13

Common name	Productive licences	Quantity	Units*	Average price/ kg or individual	Value
Barramundi	6	1190	tonnes	$10.51	$12,510,017
Marron	175	52	tonnes	$29.06	$1,501,284
Mussels	8	243	tonnes	$4.19	$1,017,041
Yabbies	7	19	tonnes	$21.49	$415,461
Silver perch	10	13	tonnes	$19.72	$254,561
Koi carp	5	25210	No.	$5.76	$145,094
Rainbow trout	6	4	tonnes	$14.97	$63,956
Ornamental fish	6	19683	No.	n/a	$60,705
Goldfish	4	12975	No.	$2.84	$36,793
Ornamental crustaceans	5	1287	No.	n/a	$8,138
Other species with <5 producers**	<5	45	tonnes	n/a	$770,734
Algae	<5	**			**
Total (not including algae or pearls)					$16,783,784

* Tonnes refer to whole weight

** Industry figures have not been included to protect the confidentiality of individual producers, as there are less than five productive licensees.

Data Comparisons Over the Past Seven Production Years (2006/07-2012/13)

AQUACULTURE PRODUCTION TABLE 2

Estimated quantity of growout production of aquaculture species/categories in Western Australia over the past seven financial years.

Common name	Units	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Barramundi	tonnes	43.2	365.9	455.2	433	862.5	1 126.6	1 190.4
Mussels	tonnes	621.9	481.2	433.5	506.5	364.9	349.8	242.6
Marron	tonnes	58.1	51.1	52.8	53.9	51.1	50.5	51.7
Yabbies	tonnes	87.9	60.8	44.1	46.7	19.7	18.8	19.3
Silver perch	tonnes	26.5	16.9	28.5	27.2	18	14.1	12.9
Rainbow trout	tonnes	11.7	13.3	11.7	7.5	11	4.2	4.3
Ornamental fish & crustaceans	No.	61 492	55 047	50 598	46 425	21 167	24 908	20 970
Koi carp	No.	30 124	35 620	34 270	44 787	39 944	21 366	25 210
Goldfish	No.	35 836	33 918	36 199	15 785	11 448	8 624	12 975
Other species with < 5 producers	tonnes	65.2	97.2	94.9	94.2	75	97.4	44.7

AQUACULTURE PRODUCTION TABLE 3

Estimated farm gate value ($) of growout aquaculture species/categories in Western Australia over the past seven financial years.

Common name/ Category	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Barramundi	$ 467 280	$3 870 071	$4 793 106	$4 512 123	$8 391 579	$11 135 223	$12,510,017
Marron	$1 387 449	$1 298 672	$1 434 494	$1 445 252	$1 418 951	$1 443 954	$1,501,284
Mussels	$1 811 298	$1 531 849	$1 618 594	$1 870 531	$1 357 009	$1 367 470	$1,017,041
Yabbies	$1 381 248	$1 059 532	$ 810 608	$ 760 595	$389 920	$376 830	$415,461
Silver perch	$ 317 275	$ 245 157	$ 405 506	$ 435 624	$310 977	$253 669	$254,561
Koi carp	$ 137 195	$ 160 597	$ 168 279	$ 184 708	$173 928	$113 751	$145,094
Rainbow trout	$ 105 391	$ 135 007	$ 140 422	$ 101 681	$133 257	$61 012	$63,956
Ornamental fish & crustaceans	$ 294 308	$ 237 408	$ 276 986	$ 230 856	$108 023	$57 715	$68,843
Goldfish	$ 65 536	$ 80 732	$ 73 992	$ 52 139	$32 771	$25 759	$36,793
Other	$ 883 044	$1 554 289	$1 715 130	$1 018 211	$1 024 396	$1 337 601	$770,734
Total (not including algae & pearls)	$6 850 022	$10 173 312	$11 437 116	$10 611 720	$13 304 811	$16 173 311	$16,783,784

APPENDIX 3
Research Division - Other Activities
Activities of the Pemberton Freshwater Research Centre and the Aquaculture & Native Fish Breeding Laboratory 2013/14

C. Lawrence, T. Church and R. Duffy

The Department of Fisheries Pemberton Freshwater Research Centre (PFRC) is the largest freshwater hatchery and research facility in Western Australia. Located on the Lefroy Brook in Pemberton it consists of two neighbouring sites, the original PFRC hatchery and the Dr Noel Morrissy Research Ponds located on Thomson's Flat. The original PFRC hatchery site contains 10 earthen ponds, 22 concrete ponds, 36 research tanks, fish hatching and larval rearing troughs. The nearby Dr Noel Morrissy Research Ponds on Thomson's Flat feature 25 earthen ponds, ranging in size from 150m^2 breeding ponds to 1000m^2 commercial growout -scale ponds, 28 tanks and a post-harvest handling facility. This site also includes an area that is leased to Forest Fresh Marron for processing and marketing the product from over 60 local marron growers.

PFRC staff are responsible for the maintenance and production of native fish, crayfish and trout at the facility. They are also responsible for stocking trout into public waters and packing trout and marron for sale to commercial farmers. Efficient management and operation of a large production and research facility for fish and crayfish such as PFRC requires a high level of expertise. As a result PFRC staff provide a key regional extension service to aquaculture, recreational fishing and biodiversity client groups. In 2010/11 as part of the NRM funded hatchery infrastructure modifications a front office has been allocated for public enquiries, community education material and the recommencement of tours of the facility by the public. The community education material on the Department's activities in the region will be developed when resources permit. Once complete it will enable the PFRC hatchery to recommence public education tours.

PFRC provides facilities, expertise and stock to support research and industry development in the four key areas of i) conserving and recovering biodiversity, ii) recreational fishing, iii) aquaculture and iv) freshwater fisheries.

Key PFRC projects in 2013/14 are briefly discussed below:

Trout production for recreational fishing, aquaculture and research

Trout production at PFRC provides fingerlings and yearlings for recreational fishing, aquaculture and research. Two species of trout are produced at PFRC, brown trout (*Salmo trutta*) for recreational fishing and rainbow trout (*Oncorhynchus mykiss*) for both aquaculture and recreational fishing.

In 2013/14 the PFRC produced 694,000 fry. These consisted of 680,000 rainbow trout fry and 14,000 brown trout fry, representing an increase in production of 3.2% and a decrease of 26% respectively, compared with 2012/13. The majority of production (67%) consisting of 454,000 rainbow trout fry and 12,000 brown trout fry was stocked into public waterways to support recreational fishing. A further 190,000 rainbow trout (28%) were sold to individuals and clubs for stocking private farm dams, to support recreational fishing and tourism operations and for licensed aquaculture production. There was a 12% increase in sales from PFRC in 2013/14 to 190,000 up from 168,000 in 2012/13.

50,000 sterile triploid rainbow trout were produced at PFRC in 2013/14 which were supplied to licenced aquaculture producers and fishing associations. The remaining 38,000 diploid trout produced (5%) were retained for future brood stock for PFRC, yearling stocking, and research.

In the winter-spring months of 2013 and May-June 2014 27,600 (29,450 in 2012/13) rainbow yearlings and 1,000 brown yearlings as well as 2,600 rainbow and 200 brown trout ex brood stock, were released to public waters for recreational fishing and control of stunted redfin perch populations.

Trout research for recreational fishing and aquaculture

In late 2006 the Department commenced a review of trout production at PFRC to consider two key factors: brown trout embryo survival and rainbow trout brood stock selection strategies. In 2007 the Department commenced research to evaluate hatchery production techniques for producing sterile triploid trout and develop improved protocols using a hydrostatic pressure chamber and tetraploids.

Brown trout embryo survival

In 2005 brown trout embryo survival was sub-optimal, however after consulting with stakeholders, prior to PFRC disposing of this valuable line, that is highly regarded by recreational fishers, Research Division staff commenced a study to confirm the extent of this problem and determine the contributing factors. This research can only be undertaken during the brief spawning period each year. Factors investigated included poor sperm motility, water quality and climate change.

Investigations by the Department into brown trout sperm motility showed that some trout were not producing motile sperm. This resulted in modifications to hatchery protocols to include assessment of sperm quality prior to egg fertilisation. In 2009/10 sperm motility assessment using basic visual evaluation of sperm quality resulted in a 500% improvement in brown trout egg fertilisation rates. However, visual assessment of sperm motility is labour intensive. Consequently sperm motility assessment was postponed until the purchase of computing equipment and software. Computer Assisted Sperm Analysis software (CASA) was purchased by the Department in late 2010. This software enabled research staff to efficiently analyse and quantify trout

sperm fitness during the 2013 spawning season.

Rainbow trout brood stock selection

The current breeding strategy for both rainbow and brown trout at PFRC focuses upon random selection of brood stock. However, trout production at PFRC has two key client groups with different objectives, recreational fishing and aquaculture. Therefore, it is likely that breeding objectives for these two groups may be different. Accordingly Research Division staff held discussions with both major client groups to establish and prioritise breeding objectives. This will ensure that in coming years, brood stock selection strategies at PFRC can be implemented to produce trout with traits that specifically meet the needs of key client groups.

The genetic line of rainbow trout at PFRC is unique. In 2008/09 staff completed a series of temperature tolerance experiments that demonstrated that the PFRC rainbow trout genetic line can withstand water temperatures of up to 28°C without any mortalities. This temperature tolerance is superior to most domesticated lines elsewhere and is significant in regards to adapting to global warming. Due to resource limitations between 2009-2012 the commencement of a trout selective breeding program to further increase temperature tolerance had to be delayed. In 2012 a Canadian based research team, with expertise in trout temperature physiology and genetics, developed a collaborative project with PFRC to undertake research into temperature tolerance of Pemberton trout. The laboratory work was completed in 2013 and is currently undergoing analysis.

Sterile triploid trout production

Triploids are valuable for both stocking and the environment as they cannot reproduce and continue to grow after reaching sexual maturity. The PFRC hatchery has produced triploids for over 20 years using temperature shock. However, temperature shocking is known to have considerable variability in triploidy rates.

Pressure shock provides less variability in ploidy rates than temperature shock. Over the past three years Department of Fisheries Researchers at PFRC have designed and built a system capable of delivering precise pressure shocking of embryos in a safe and reproducible manner. In the past two years researchers have developed and refined protocols for producing both triploids and tetraploids using hydrostatic pressure. In 2012 ploidy rates were validated by researchers from The University of Western Australia, with pressure shock (80%) providing better triploid rates than temperature shock (70%). Furthermore, researchers successfully produced tetraploid trout, albeit in low numbers. Department of Fisheries researchers are undertaking further work with colleagues from The University of Western Australia to develop and validate a more efficient technique of quantifying the percentage of triploids , diploids and tetraploids from embryo samples.

Establishment of a second repository for temperature tolerant trout lines

Given the value of the temperature tolerant rainbow trout line, a second repository was established at the UWA owned and Departmental run, Shenton Park, Aquaculture and Native Fish Breeding Laboratory. Fish were successfully held at the facility over summer despite air temperatures in excess of 40^{o}C and water temperatures of approximately 28^{o}C. The ability to successfully establish this line through the heat of summer will reduce the risk of loss of trout with the highest known temperature tolerance of any stock worldwide.

Native and endangered fish conservation and biodiversity research

In response to a declining prevalence of native fish in the Southwest, Department of Fisheries researchers have established brood stock populations of two endemic species pygmy perch (*Nannoperca vittata*) and western minnows (*Galaxias occidentalis*) at PFRC. The aim of this research is to develop large-scale pond production techniques for these species to 1) enable stocking of public and private water bodies in the Southwest, 2) develop and validate the most efficient production strategies for each species, and 3) transfer this technology to achieve captive breeding of two listed species (*Galaxias truttaceus* - Critically endangered and *Nannatherina balstoni* - Vulnerable to extinction).

Western minnow (*Galaxias occidentalis*)

In 2012 PFRC successfully achieved large scale spawning of the western minnow (*Galaxias occidentalis*) in hatchery ponds. Over 6,000 juveniles were produced from this pilot research project. The technology developed is now being applied to further increase mass production of western minnow for restocking and transferred to breeding the critically endangered trout minnow (*Galaxias truttaceus).*

One of the challenges of captive breeding for release programs is to ensure that genetic drift within the hatchery environment does not result in progeny that are less fit for survival in the wild. At PFRC an innovative strategy developed by Department of Fisheries researchers to address this challenge received NRM funding in 2010. This strategy is based upon the upstream spawning migration of native fish. This means that juveniles produced in the PFRC hatchery and tagged, if released into the adjacent Lefroy Brook, when they reach sexual maturity will return to the hatchery to spawn. From several thousand fish released only those genetically fit enough to survive in the wild will return to PFRC to spawn. The NRM funding enabled a fish ladder supplied with water from PFRC to be constructed between the hatchery and the Lefroy Brook. In future years, by releasing juveniles produced at PFRC at the mouth of the fish ladder, after spending two years in the wild they will now be able to swim back up the fish ladder and into the hatchery to provide the next generation of PFRC broodstock.

During the planning stage of the PFRC fish ladder, consultation between Department of Fisheries researchers and Department of Water engineers identified critical knowledge gaps in the design specification's required for native fish to successfully migrate up a fish ladder. While there are proposals by university researchers to commence testing some design specifications (i.e. swimming ability) using laboratory scale swim chambers, the lack of a full scale fish ladder for research has limited the variables that can be examined. Consequently, the PFRC Fish Ladder has been designed so that it can not only be used to validate results from laboratory experiments, but can also be modified to test the effects of variables such as board height, pool length, pool depth, barrier type, flow rate etc. in a full scale working model. The information obtained from these experiments will lead to improved and scientifically validated designs for fish ladders in WA.

Pygmy perch (*Nannoperca vittata)*

In 2012 pygmy perch were spawned in tanks at PFRC following the protocols developed and refined at the Aquaculture and Native Fish Breeding Laboratory, in Shenton Park. This technology has now been scaled up to mass production in ponds on Thomson's Flat and at Shenton Park to produce fish for restocking. Techniques developed for breeding the pygmy perch are now being transferred to the related Balston's perch (*N. balstoni*), which is listed as vulnerable to extinction.

It is thought that the decline in prevalence of native fish is related to the increased spread of introduced *Gambusia* (*Gambusia holbrooki*), but research at PFRC and a NRM funded survey by Department of Fisheries researchers in 2010 indicates that other factors may also be responsible. Although *Gambusia* were originally introduced to control mosquito populations, it appears that other native fish species consume more mosquito larvae. Therefore, while production and stocking of endemic species has direct conservation and biodiversity benefits, it is also likely to result in human health benefits through a reduction in mosquito borne diseases such as Ross River virus.

Endangered/Threatened/Protected native fish species

Broodstock populations of two endangered native fish species the trout minnow (*G. truttaceus*) listed as critically endangered, and Balston's pygmy perch (*N. Balstoni*) listed as vulnerable to extinction, are being established at PFRC and the Aquaculture and Native Fish Breeding Laboratory in Shenton Park. They will be managed using the same suite of husbandry techniques that Department of Fisheries scientists have developed, and shown to be effective, for the production of the related western minnow (*G. occidentalis*) and pygmy perch (*Nannopera vittata*). In addition to establishing a living gene bank before these species become extinct in the wild, the focus of this project is to close their lifecycles, develop large scale production techniques and restock waterbodies within their original distribution.

Establishing key genetic lines for conservation and restocking

The Department of Fisheries NRM survey showed that genotypes of pygmy perch and western minnow among water bodies north of Collie are similar. However, those south of Collie are different from the northern populations and show increased variation among catchments. Consequently, in 2012/13 the breeding program for these two species was split into two major populations, a northern genetic line at Shenton Park Aquaculture & Native Fish Breeding Laboratory for restocking the Swan Coastal Plain; and a southern genetic line at PFRC. Collection of these stocks has commenced.

Mosquito predation

While it is widely accepted that native fish consume more mosquito larvae than the introduced mosquito fish (*Gambusia*) this has yet to be scientifically verified. In 2013 Department of Fisheries researchers quantified the mosquito larvae consumption of key native fish and *Gambusia*. These results will also determine which species is the most suitable for stocking artificial water bodies in which mosquito control, rather than biodiversity, is the primary objective.

Trout predation of feral species

A trial to investigate trout predation of the feral mosquito fish (*Gambusia*) was undertaken at the Aquaculture & Native Fish Breeding Laboratory. This research investigated the relationship between size of trout and rates of consumption. Analysis is ongoing, however early results suggest that presence of trout in water bodies will have a significant impact on reducing mosquito fish numbers.

Native and endangered crayfish conservation and biodiversity research

The key focus of this program is to establish a living gene bank and breeding population of the critically endangered "hairy" Margaret River marron, before it becomes extinct in the wild. Department of Fisheries researchers working in collaboration with The University of Western Australia have developed a molecular technique to distinguish pure "hairy" marron from hybrids using real-time PCR. This is being used to select broodstock marron for the captive breeding program at both PFRC (traditional pond techniques) and the Aquaculture and Native Fish Breeding Laboratory, in Shenton Park (intensive hatchery techniques).

The department has successfully spawned, and is in the process of rearing, offspring from genetically pure hairy marron. The offspring will form the basis of a captive population that will be used to establish secure populations in the wild and supplement the existing populations.

In addition, a living gene bank representing marron populations from two other river systems are bred and reared in the captive breeding program at PFRC. These broodstock represent the genetic biodiversity of the ancestral Pemberton strain upon which the WA aquaculture industry has been developed, and the rare blue marron. Their progeny are used for 1) marron farmers wishing to increase the genetic diversity of their stocks, 2) wild fisheries research involving the release and recapture of tagged juveniles in the recreational marron fishery, and 3) where appropriate, restocking of both catchments and farm dams in the region.

Marron aquaculture research and development

In 2006 the FRDC project 2000/215 "Improved performance of marron using genetic and pond management strategies" was completed. Working with industry on commercial marron farms Research Division staff validated and established current best practice farming techniques. This showed that correctly constructed and professionally managed marron farms achieved production levels twice that of those which do not follow best practice.

The project also showed that poor brood stock selection, where farmers sell their largest marron and breed from the remaining slower growing animals had reduced the growth rate of marron on commercial farms. To address this, the Research Division staff initiated a selective breeding program that resulted in a 100% improvement in growth rate. In 2007 PFRC produced around 25,000 juveniles for sale to industry. A repository population of the best performing mass and

pedigree selected genetic lines was retained at PFRC for future selective breeding and sale of progeny to industry. Increased demand for these juveniles, combined with limited supply from industry, is likely to necessitate re-establishing the selective breeding program at PFRC in the future.

Summary

In 2013/14 the Freshwater section of the Department has returned to normal. In 2012/13 increased requirements to provide scientific support to i) policy development (translocation, biodiversity, biosecurity, recreational angling) and ii) Water Corporation projects, as well as the conclusion of an 18-month rebuilding project at the Shenton Park based facility, required a reallocation of resources from research activities. Core activities for recreational and aquaculture stakeholders, including trout production and monitoring of recreational marron fishery were delivered. In addition, advanced research into mosquito fish control, establishment of unique genetic lines of native species, investigation of breeding techniques and role of native fish in mosquito control have been investigated.

Activities of the Fish Health Unit during 2013/14

The Fish Health Unit of the Department of Fisheries was formed in 1988 following an outbreak of disease in the state trout hatchery. The unit is based at South Perth within the Animal Health Laboratories of the Department of Agriculture and Food, bringing economies of scale through sharing of equipment. The unit is permanently staffed by one full-time principal scientist, one full time and one part-time fish pathologist, one research scientist, one laboratory manager, and two part-time technical officers.

The unit is accredited to ISO 17025 and provides a diagnostic service to the seafood industries in Western Australia, undertakes disease surveillance for key fisheries, investigates 'fish kills', contributes to policy advice developed by the Department, carries out research on diseases of aquatic organisms and has a minor extension role. In addition, protocols for high health hatchery status have been developed and adopted by key industries. Key activities and achievements of the unit during 2013/14 were as follows:

The fish health laboratory received a total of 160 diagnostic cases during 2013/14.

The provision of export health certificates for yabbies and marron has continued its downward trend since 2002, when 55 certificates were issued, to none for the last four years. This decline in export activity is due to the continuing drought and to changes in product destinations within the industry.

The provision of pearling translocation certificates declined from 8 to 6 in this reporting period. This is partly because a hatchery in Darwin is supplying more spat to Western Australia than in previous years.

There were 11 cases of notifiable diseases reported in 2013/14. Eight notifications related to records of Megalocytivirus in ornamental fish in quarantine facilities at the border following importation from overseas. The notifiable bacterium *Edwardsiella ictaluri* was isolated from *Helostoma temminki* (Kissing gourami) in quarantine at the border. The endemic disease epizootic ulcerative syndrome (EUS) was diagnosed in black bream from the Swan and Canning Rivers on two occasions in late 2013. The spring of 2013 was wetter and warmer than usual and EUS outbreaks appeared to be more severe and prolonged than usual.

In collaboration with staff from the Department of Water, 5 reports of 'fish kills' throughout the State were investigated. Most 'fish kills' were due to poor water quality resulting from low water levels in autumn or natural events compounded by man-made water flow disturbances. In May 2014 the Indian Ocean Territories were re-visited for updated fish kill training under agreement with the federal government. Fish kill training was provided by members of the Fish Health Unit for personnel who may need to respond to fish kill incidents. In 2013/14 training occurred within the metropolitan area and in several regional centres.

A project funded by the FRDC aimed at investigating the cause of disease in pearl oysters (*Pinctada maxima)* was commenced. The project is in collaboration with Macquarie University and the Pearling industry and aims to exploit recent advances in molecular sequencing technology to identify the genetic signature of pathogens associated with Oyster Oedema Disease (OOD). This information can be used to investigate the role of such pathogens in contributing to disease and to potentially develop diagnostic tests to support its management.

A 3 year FRDC project 2011/005 to examine WA prawn samples for virus continued. This project aims to identify emerging pathogens of potential significance to both wild fisheries and any potential developing prawn aquaculture industry.

A range of national committees including: the national Subcommittee for Aquatic Animal Health; Aquatic Animal Health Project under the Australian Biosecurity Intelligence Network; and Biosecurity Australia frequently seek the expertise of the Fish Health Unit. This reflects the greater emphasis on national coordination and consultation on aquatic animal health issues.

The laboratory continued in its role as one of 7 regional resource centres for aquatic animal health within the Network of Aquaculture Centres (NACA) in the Asia-Pacific.

Members of the group also attended and presented at the FRDC Second Australasian Scientific Conference on Aquatic Animal Health in Cairns, Australia in July 2013. This conference represents an important opportunity to network with fish health professionals from across Australia and worldwide.

Activities of the Marine Biosecurity Research and Monitoring Group during 2013/14

Marine Unit

The Marine Biosecurity Research and Monitoring Group currently monitors high risk ports around the State and has developed research programs to increase our knowledge of the marine pest threat to our State waters.

Introduced Marine Pests

Introduced marine species are organisms that have moved, or been moved from their natural environment to another area. Many of these organisms remain inconspicuous and innocuous causing no known adverse effects. However, they can potentially threaten human health, economic values or the environment, in which case they are then referred to as marine pests. Introduced marine species are a global problem, and second only to habitat change and loss in reducing global biodiversity (Millennium Ecosystem Assessment, 2005).

The introduction of marine species into a new region can be deliberate or accidental. Deliberate introductions may result from aquaculture practices or releases from aquariums. Accidental introductions are primarily due to shipping and recreational craft moving from country to country, with the pests being transported in ballast water, on ship hulls, or within a vessel's internal seawater pipes. Introduced marine species also arrive naturally via marine debris and ocean currents.

The impacts of introduced marine pests are wide and varied. They can predate on native and farmed species, out-compete natives for space and food, alter nutrient cycles and lead to a loss of diversity in local species. In addition to environmental consequences, introduced marine pests have the potential to harm human health (e.g. cholera, paralytic shellfish poisoning), negatively affect commercial fish and seafood species, negatively affect amenity and recreational activities and reduce the fuel efficiency for all vessel types (hull fouling organisms). With increasing human population and associated travel, transport and trade, the risk of introducing new species is likely to grow (Convention on Biological Diversity, 2005).

Early detection of an introduced marine pest is vital if we are to have any chance of eradicating it before it becomes established. There has only been one introduced marine species that has been successfully eradicated to date in Australia, the black striped mussel which was found in Darwin Harbour in 1999. This program of eradication cost more than $2M, but the mussel threatened the $225M (value of production in 1998) pearling industry. If eradication is not an option then other management controls can be put in place, such as community education regarding boating habits and routines, quarantining areas and managing vessel movements between locations.

As an ocean bound nation Australia relies heavily on maritime transport, with over 95% of our imports and exports carried by sea. The large ocean going vessels that transport these goods represent one of the largest vectors of introduced species. For these reasons our ports and marinas become high risk areas for the introduction of a marine pest. The Commonwealth Government, together with the states and territory have developed a national system of policies and procedures to try and reduce the risk of marine pests arriving in Australian waters. Part of this system includes the monitoring of high risk ports, which are those ports that receive large numbers of vessels, high risk vessels (such as dredges) or are geographically close to areas with known invasive marine species.

The monitoring and research activities of the group are aimed at preventing or minimising further introductions of marine pests, and advocating control measures where they do exist.

Monitoring and Surveillance

The Marine Biosecurity Research and Monitoring Group is actively involved in developing and implementing monitoring programs for marine pests along our WA coast using a suite of tools. These programs adhere to the Australian Marine Pest Monitoring Guidelines and have been endorsed by the Commonwealth. These programs occur every two years and have been implemented in Fremantle, Port Hedland, Dampier, Geraldton and HMAS Stirling (Garden Island, Defence Services Group) in 2013/14. The Marine Biosecurity Research and Monitoring Group has also developed targeted supplementary monitoring programs, to complement the above, which occur in the off years.

The Marine Biosecurity Research and Monitoring Group are developing a marine pest incursion response plan for HMAS Stirling on behalf of the Garden Island, Defence Services Group.

Early warning system

The Early Warning System uses arrays to examine early stage settlement of marine organisms. By examining these arrays at 3 monthly intervals it provides a reliable mechanism for the early detection of any marine pests. Settlement arrays are an established methodology currently being used by the Marine Biosecurity Research and Monitoring Group as a complementary method for marine pest monitoring in Dampier, Port Hedland, Esperance and Fremantle Ports and at HMAS Stirling. These arrays are simple structures designed to act as extra surfaces for organisms to settle on, using 10cm x 10cm plates and mops as collectors. In addition to the deployment of the settlement arrays, twice a year shoreline searches are carried out and crab traps are deployed.

Surveillance in response to detection

Charybdis japonica

In 2012 three male specimens of the invasive Asian paddle crab *Charybdis japonica* were caught by members of the general public in the Swan River estuary and handed in to the Department of Fisheries Biosecurity team over a period of several months. This triggered extensive trap-based and diver surveillance of the target area in the lower reaches of the estuary. Over 8500 trapping hours and several days of diving surveillance failed to detect any more *C. japonica*. Follow up surveillance operations were conducted at 3, 6 and 12 month intervals after the initial surveillance operation, bringing the

total number of trap hours to more than 20 000. To date no further specimens of *C. japonica* have been detected by either the Department or the general public.

Didemnum perlucidum

In 2011 the Department were alerted to the presence of *D. perlucidum* in our waters. This species is considered non-native to Western Australia and based on current knowledge has only been recorded once previously in Australia (on a vessel in NSW).

The initial detection of this species triggered further investigation by the Department's Marine Biosecurity Research and Monitoring Group who have since found the species to be present in many ports and marinas from Esperance to Broome. It has also been confirmed that this species is present as a common component of hull fouling on vessels traversing the coastline.

The widespread distribution and extensive growth of this species raises biosecurity concerns for the Department. *Didemnum perlucidum* is a heavy fouling species that may cover and smother other benthic assemblages. *Didemnum perlucidum* displays all the characteristics typical of a pest species: high growth rate, early maturity and extremely high fecundity. Furthermore this species may spread asexually, both through lateral expansion at the edges of the colony as well as through pieces breaking off and establishing elsewhere.

Previously this pest species has been confined to artificial structures such as jetty pylons and vessels. Recent surveillance by the Marine Biosecurity Research and Monitoring group has detected this species colonising the seagrass *Halophila ovalis* in the Swan River and the seagrass *Posidonia* in Albany. This is the first record of this species colonising natural surfaces. The group are currently monitoring the effect this pest may be having on the seagrass and ongoing monitoring to further investigate impacts is planned. *Didemnum perlucidum* is a very difficult species to identify and differentiate from other native species which are known to exist in Australian waters. The Marine Biosecurity Research and Monitoring Group has developed identification capabilities for this species based on characterisation of its DNA. Analysis of populations detected in Western Australia indicates that this species is genetically identical to specimens originating from Brazil. Initial examination of *D. perlucidum* populations sampled along our coast suggests very low genetic variation which is consistent with a recent appearance of this species in Western Australian waters.

Established species control program

In 2008 the invasive algae *Codium fragile* ssp *fragile* was detected in Albany, Western Australia. This species is regarded as one of the most invasive algae species in the world. The algae goes by many names such as dead man's fingers and the oyster thief for its reported impact on commercial oyster farms. The species is prolific once established and readily spreads throughout its new location. In 2014 the Marine Biosecurity Research and Monitoring Group undertook a delimiting survey of this species in and around the vicinity of the Albany tug pen where it had been reported. The algae was confined to an area approximately 4m wide by 80 m long and was extremely patchy in its distribution. Divers proceeded throughout this range and removed all visible plants as part of an ongoing control program. The team will return in summer to determine if there is any regrowth and to target any 'missed' plants. It is hoped that with sufficient attention we may be able to remove this species from WA waters.

Research programs

Likelihood analysis

The Marine Biosecurity Research and Monitoring Group have completed their analysis of vessels entering WA ports. This research examined the types and number of commercial vessels that visit our ports from domestic and international last port of calls, duration of the vessels stay, duration of the voyage, the marine pest status of international and domestic ports and environmental matching between the last port of call and the WA port(s) visited. This research provides an analysis of the likelihood of a potential marine pest introduction to individual ports based on the above data that will inform management and policy.

Recreational vessel study

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

Vessel wrapping

Preventative measures such as maintenance of a clean vessel hull is widely acknowledged as more effective in curtailing invasions of marine pests than are eradication or control measures. The Marine Biosecurity Research and Monitoring Group completed a trial in collaboration with South Australian researchers to ascertain the efficacy of wrapping a recreational vessels hull in eliminating/killing biofouling. Results were very promising for these small vessels. Further successful trials were completed on the efficacy of wrapping structures such a pylons to kill fouling which are currently being written up for publication. The use of wrapping has also been successfully implemented by the Biosecurity Compliance group.

Crab condos

Baited crab traps have been used in many decapod sampling regimes around the world and specifically target larger predatory/scavenger crustaceans. Crabs are lured inside the traps by an attractant, typically fish-bait and stay inside until the trap is recovered. This technology is effective at capturing larger and aggressive crab species: however, juvenile, small or non-carnivorous species are generally excluded from such devices. A device nick-named the 'crab condo' was evaluated by the group to determine its efficacy in detecting these crab types and the results have been published in the international journal Management of Biological Invasions. This methodology is now included in our marine pest

monitoring and has been suggested to be included as part of the Australian National System program.

Crab traps and crab behaviour

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

Indian Ocean Territories 2012/13

The Marine Biosecurity Research and Monitoring Group are currently conducting two projects in the Indian Ocean Territories.

Marine pest surveillance

The introduction and spread of marine pests poses a serious threat to native biodiversity and can have widespread effects on both our economy and health. The Marine Biosecurity Research and Monitoring Group developed a targeted marine pest monitoring program for Christmas Island in 2010. The aim was to detect the presence of introduced marine pests (IMPs) using a suite of tools. As part of the ongoing biennial project the Marine Biosecurity Research and Monitoring Group completed a large-scale marine pest monitoring program in Christmas Island port in late 2012. No marine pests were detected during the 2012 survey. The team will resurvey the island in late 2014.

Marine pest research

The Marine Biosecurity Research and Monitoring Group have completed their analysis of vessels entering Christmas Island. This research examined the types and number of commercial vessels that visit the Island from domestic and international last port of calls, duration of the vessels stay, duration of the voyage, the marine pest status of international and domestic ports and environmental matching between the last port of call and Christmas Island. This research provides an analysis of the likelihood of a potential marine pest introduction to Christmas Island based on the above data that will inform management and policy.

Activities of the Freshwater Biosecurity Research Program 2013

Prepared by: C. Bird, A. Harris & R. Duffy

Background

A 2010 NRM funded project which surveyed 114, of over 4000 listed permanent lakes and swamps of the southwest coastal plain from Geraldton to Busselton, found that fish abundance in the majority of lakes surveyed was dominated by non-native species. The survey detected two new non-native fish species and a new location for a previously detected species. This survey identified the need for a more comprehensive survey program.

Prior to 2013 there were 16 finfish and 2 crustacean, non-native, freshwater species recorded in Western Australia (WA) (Freshwater Biosecurity Table 1). Most of these species successfully reproduce and are therefore considered established pests. Golden Perch and Silver Perch are the only two introduced species in WA that are yet to have known self-sustaining populations; this does not necessarily imply they are unable to breed in WA.

Among vertebrates, freshwater fishes are one of the most commonly introduced species. Ornamental fish in particular account for a majority of the recent fish introductions to Western Australian freshwater ecosystems. Over the past 20-30 years there has been a steady increase in the number of exotic freshwater ornamental fish species that have become established in Australian waterways. All introduced freshwater species found in WA may have an adverse effect on the survival of native species via competition for resources, predation as well as habitat modification.

Management Arrangements

The Department of Fisheries oversees the management of risks associated with the translocation of live fish into and within the State. The most common activities that require the translocation of live fish include commercial aquaculture, the live seafood/restaurant trade, non-commercial aquaculture (including the stocking of farm dams) and the aquarium trade. The approvals process involves a risk assessment for those species that are not on the Department's White Lists. If the risk assessment determines that the translocation of that species is of an acceptable level of risk to the State, Translocation Approval is granted and with a set of conditions that must be followed. Applications are refused when the risk is assessed as being too high.

The prohibited release of translocated species into Western Australian waterways is typically human assisted. Aquarium release of unwanted fish, is a common pathway for these species to be introduced into waterbodies and catchments, as is the deliberate release for recreational angling purposes. Managing the release of species in this manner is difficult.

Community Engagement

In an attempt to reduce the introduction of unwanted species in Western Australian waterways the Department has put a strong focus on community education and engagement in 2013. The 'don't dump that fish' program was launched in October 2013. The campaign saw 'don't dump that fish'

posters, brochures and fish bag stickers distributed to 138 participating aquarium retailers around the State and at 6 community events. The program also received wide media coverage, featuring in 25 media outlets (12 online websites/forums, 2 radio reports, 1 television report and 10 newsletter and magazine publications). As a result, the wider community are becoming more aware and educated on the impacts of releasing unwanted aquarium fish, snails and plants into open waterways, toilets, drains or the ocean.

The Department attended 20 community events around the State distributing materials and engaging with a wide range of stakeholders to raise awareness, educate and inform them about freshwater biosecurity issues.

Additionally, 2013 saw the launch of WA PestWatch, a free application to improve aquatic biosecurity. WA PestWatch can be used on a smart phone, tablet device or accessed via the web and helps members of the public report sightings of potential pests while they are out enjoying the State's oceans and waterways. This app widens our much needed surveillance of newly introduced pests in WA to include the entire community, using a method that is easy to use, fast, includes photos for identification, has accurate GPS data, and automatic mapping of the report.

The Department has increased freshwater compliance activities to prevent new introductions and continued regulations which prevent a large number of high risk ornamental fish species that arrive without translocation permits from gaining entry into Western Australia.

Staff from the Research Division, in addition to staff from all other Divisions across the Department, have formal training in incident management so that there is a preparedness for response to potential biosecurity incidents and emergencies. In tandem with the incident management training, the Department has refined its risk assessment processes and incident management protocols.

Sampling methodology

The majority of sampling in the Perth area in 2013 was undertaken using fyke nets – a trap net that has a wing attached to the bank, which leads to a series of hoops and funnels. These nets are generally unbaited. It is accepted that not all fish species are susceptible to capture by fyke nets, however, it is the most appropriate cost effective method for the large number of locations to be sampled. Many of the locations are also often unsuitable for sampling by other methods such as seine netting, electrofishing, gillnets and opera house traps due to habitat type, by-catch and staff safety. However, on occasions, sampling methods included the use of electrofishing, opera house traps, fish box traps or gillnets where appropriate. The fyke nets used by the Department are fitted with a float ring to provide access to the surface for any air-breathing animals captured.

Biosecurity Surveys

During 2012 the Freshwater Biosecurity Research Unit was formed to undertake comprehensive surveys, respond to pest species reports and undertake control measures of introduced freshwater species where required. The survey work in 2013, a continuation from the 2012 monitoring, was concentrated in the Perth-metro region (Swan/Canning coastal plain). This area has been identified as high risk due to previous pest fish detections, the large urban population and the extensive lake and drainage systems connected to the Swan/Canning Rivers.

There are approximately 1200 permanent lakes listed for the Perth-metro region, comprised of natural lakes and swamps, man-made or highly modified lakes, water compensating basins as part of drainage management and permanent pools in ephemeral systems. Review of recent late summer aerial photos would indicate that only approximately half of these now retain water all year. Survey work of these lakes by the dedicated Freshwater Biosecurity Research Unit commenced during 2012 with priority being given to lakes around existing known pest species populations. Location visits, on occasion, found some lakes to be dry, too shallow or on private property where access was unable to be obtained. Where necessary for the detection of introduced fish, creeks, rivers and drains connected to these lakes were also sampled.

During the 2013 survey a total of 176 sampling occasions were conducted, of which 26 were repeat samplings at 15 locations (Freshwater Biosecurity Table 2). In early 2013, a single Murray Cod, *Maccullochella peelii* was captured in Harmony Lake, Atwell. Murray Cod were stocked into many public and private waters outside its natural range, and into a number of localities in south-western Australia in the late 1800s; e.g. the Swan-Avon River and Lake Grassmere (now known as Lake Powell, Albany). Since that time, however, any established populations of Murray Cod are believed to have disappeared. A follow up sampling event at Harmony Lake failed to catch any more Murray Cod, however at least two more sampling occasions are planned to ensure no additional Murray Cod remain. A large predatory species such as this could decimate WA native fish populations.

Survey work conducted in late 2013 revealed the Freshwater Eel-tailed Catfish *Tandanus tandanus* to be present at a second location in the Perth-metro region – Ollie Worrell Reserve Lake, High Wycombe (the first population of the introduced Catfish, detected during the 2010 NRM survey, being found in Marmion Reserve Lake, Myaree). Three individual Catfish, all approximately 40cm, were removed from Ollie Worrell Reserve Lake upon detection. Further sampling will occur in 2014 at Ollie Worrell Reserve Lake, the adjacent wetland area of Munday swamp and the drainage channel joining the two waterbodies to confirm eradication. During the wet season species from Ollie Worrell may move into Munday swamp via the drainage channel. The connectivity of Ollie Worrell to Munday swamp is of particular concern, as once in Munday swamp, species would be able to follow creek and drain linkages directly into the Swan River.

Freshwater Biosecurity Research staff continued with control measures in 2013 for the population of Catfish in Marmion Reserve Lake. Following the population assessment of the Catfish in 2012, several fish-down efforts were conducted in 2013, which removed over 1,800 Catfish from the lake. Continued efforts are aimed at verifying eradication of Catfish from Marmion Reserve Lake in 2014.

Impact on non-target species

The use of fyke nets for sampling can unintentionally capture non-target species, the most prevalent being Oblong Turtles, *Chelodina oblonga*. Of the 176 sites sampled in 2013,

Oblong Turtles were captured at 109 of these. A total of 574 fyke nets were used and captured 1692 turtles, all of which were returned alive to the water. Water birds were also captured in shallow waterbodies where the entrance to fyke nets was not completely submerged under water. A total of 23 water birds were captured at nine sites, all of which were released unharmed. Sampling for fish using fyke nets, is a safe method for eliminating death of non-target animals.

Pest Reporting and Response

In addition to the survey work conducted throughout the Perth-metro region (Swan/Canning coastal plain) in 2013, the Freshwater Biosecurity Research Unit also responded to a number of pest species reports. Pest species were reported to the Department via Fishwatch, WA Pestwatch, the Freshwater Fish Distribution website and direct contact with the Department of Fisheries WA. The responses to these reports were prioritised according to risk and previous known distributions of the reported species. From the reports received in 2013, nine were addressed with sampling events. The remaining reports were deemed to be of low risk or reports of species already known to be present in the system.

Of the reports attended, two were from locations outside the Perth-metro region; Wellington Dam (near Collie) and Harding River Dam (Roebourne). Three reports over eight months were received of Koi Carp *Cyprinus carpio* being sighted in Wellington Dam. While Koi Carp are known to be wide spread throughout Perth and the rest of Western Australia, this was considered a high priority due to the Western Australian Government's consideration to make Wellington Dam a Freshwater Recreational Fishing Hub. No Koi Carp were captured during the Department's survey. Wellington Dam is such a large system (approximate full surface area of 1,600 hectares) and the estimated low density of Koi Carp made capture during a one-off sampling occasion difficult. Reports of Koi Carp in Wellington Dam will continue to be scrutinised and follow up sampling undertaken if deemed necessary.

In mid-2013, a report stated that Redclaw crayfish *Cherax quadricarinatus* were in Harding River Dam *(*Lake Poongkaliyarra). Follow up sampling performed at Harding River Dam confirmed the species was indeed Redclaw. Other than the 130 Redclaw specimens captured, no other species were collected. Data from previous sampling occasions of both the Harding River Dam and surrounding waters of the Harding River suggests that many species reside in the Harding River Dam catchment area. However, data on species captured in the Harding River Dam catchment has not been published for several years, and so it is uncertain which species are present in this area today. Further sampling of the Harding River Dam catchment area would allow for a more comprehensive understanding of the risks posed by this discovery.

New Discoveries

Three of the nine reports attended to in the Perth-metro region were of particular importance to the Freshwater Biosecurity Research Unit.

A report received mid-2013 resulted in the discovery of a population of Southern Platyfish *Xiphophorus maculatus* and a snail (*Planorbella sp*) in two connected waterbodies located at Bodkin Park, Waterford. Neither species has previously been record in Western Australia. Southern Platyfish are considered a highly resilient species with the potential to become a pest, and therefore extremely difficult if not impossible to eradicate once established. The species identity of the snail (genus *Planorbella*) could not be confirmed with certainty. Positive matches were made with two species *P. tenue* and *P. trivolvis*. Sequencing of further specimens identified and vouchered by experts in Museum collections could be conducted to provide further certainty to the species level identification. Due to the nature of this case, poisoning is not an option although the Department will implement a control program using other methods in early 2014.

The discovery of a crustacean species, not previously found in the state was also the result of a public report. Several thousand Indistinct River Shrimp *Cardina indistincta* (B1), an Eastern states species, were captured in May 2013. Specimens were collected while electro-fishing a creek line along Severin Walk, near Cleaver Terrace Belmont. A broader sampling program revealed established populations of the Indistinct River Shrimp at a further two locations in Perth (Bennett Brook, Beechboro and Centenary Park, Belmont). At each location where Indistinct River Shrimp were present, the native Glass Shrimp *Palaemonetes australis* was absent. The Indistinct River Shrimp's ability to exploit habitat very similar to that of the Glass Shrimp, paired with the overlap in each shrimp's life history characteristics is likely to result in strong competition between the two species.

Sampling undertaken at Bells Rapids during late 2013, in response to a feral report of Pearl Cichlids *Geophagus brasiliensis*, confirmed the presence of the South American species. The Pearl Cichlid has been known from Perth waterways since 2006. The new location reveals that in only eight years this highly successful, invasive species has spread over approximately 20km of the Swan River.

Native fish abundance

Native fish abundance recorded from the 2013 sampling displayed a similar trend observed during the 2012 survey. Of the 176 waterbodies sampled, native species were found to be present in only 42 sites (24%). Far less waterbodies were found to contain *only* native freshwater species (2%); other sites contained introduced and native species or only introduced species. Such low frequency and abundance of natives may be due to; reduced water levels from reduced rainfall and/ or increased groundwater extraction, poor water quality (i.e. acidification, eutrophication, salinization, sedimentation as well as pollution by industrial, residential and agricultural waste), destruction of riparian vegetation, channelisation of streams in irrigation areas, and finally introduced feral fish which compete with and consume native fish. It is suggested urgent action is necessary to protect the few remnant populations before they disappear completely.

Restocking

One method to protect remnant native freshwater fish populations would be via a breeding and stocking program of lakes where native species are currently absent, but suitable conditions for survival exist. This would require considerable quantities of fish, given the high number of lakes involved in

the Perth-metro region alone (up to 560). The breeding stock for the stocking program would need to be sourced from the remnant lake stocks to ensure stocked fish possess genetic traits suitable for survival in the highly modified lakes within the metro region.

No restocking was undertaken during 2013.

FRESHWATER BIOSECURITY TABLE 1

Freshwater species introduced to Western Australia, recorded during the Freshwater Biosecurity Survey (2010-2013)

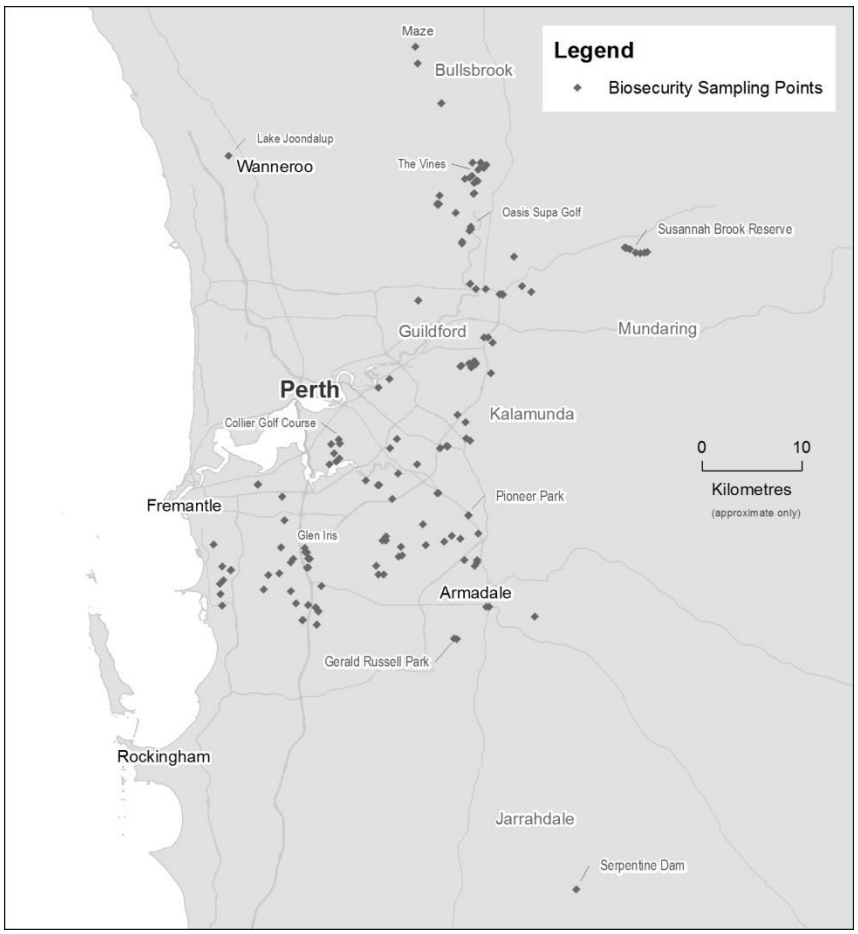
Common Name	*Scientific Name*	Origin
Finfish		
Brown Trout	*Salmo trutta*	Europe
Carp (Koi)	*Cyprinus carpio*	Eurasia
Convict Cichlid	*Amatitiania nigrofasciata*	Central America
Freshwater Eel-tailed Catfish	*Tandanus tandanus*	Eastern Australia
Gambusia/ Mosquito Fish	*Gambusia holbrooki*	Sth America
Golden Perch	*Macqaria ambigua*	Eastern Australia
Goldfish	*Carassius auratus*	Eurasia
Guppy	*Poecilia reticulata*	Sth America
Murray Cod	*Maccullochella peelii*	Eastern Australia
Pearl Cichlid	*Geophagus brasiliensis*	Sth America
Rainbow Trout	*Oncorhynchus mykiss*	Europe
Redfin Perch	*Perca fluviatilis*	Europe
Rosy Barb	*Puntius conchonius*	SE Asia
Silver Perch	*Bidyanus bidyanus*	Eastern Australia
Southern Platyfish	*Xiphophorus maculatus*	North and Central America
Spangled Perch	*Leiopotherapon unicolor*	Gascoyne
Speckled Mosquito Fish	*Phalloceros caudimaculatus*	Sth America
Swordtail	*Xiphophorus helleri*	Sth America
Tilapia	*Oreochromis mossambicus*	Africa
Crustaceans		
Redclaw Crayfish	*Cherax quadricarinatus*	Eastern Australia
Yabby	*Cherax destructor albidus*	Eastern Australia
Indistinct River Shrimp	*Caridina indistincta (B1)*	Eastern Australia
Molluscs		
Snail sp.	*Planorbella sp*	Unknown

FRESHWATER BIOSECURITY TABLE 2

Freshwater Biosecurity Sampling Results from the Perth-metro Region

Year of Sampling	2013		2012	
	Total	%	Total	%
Finfish				
Number of locations visited	176	-	140	-
Number of locations by visit dry or too shallow	8	5	9	6
Number of locations sampled	164	93	124	95
Number of locations containing finfish	134	76	119	96
Number of locations containing estuarine fish	33	19	42	34
Number of locations containing native freshwater finfish	17	10	8	6
Number of locations containing only native freshwater finfish	0	-	3	2
Number of locations containing feral freshwater fish	126	72	99	80
Number of locations containing only feral freshwater finfish	49	29	71	57
Number of new introduced finfish species detected	2	1	1	<1
Number of new locations introduced freshwater finfish detected in	1	<1	0	-
Number of new locations introduced freshwater finfish detected in	1	<1	8	6
Number of new locations introduced freshwater finfish detected in	3	2	NA	NA
Crustaceans				
Number of locations containing crustaceans	85	48	66	53
Number of locations containing native crustaceans	63	36	51	41
Number of locations containing only native crustaceans	3	2	29	23
Number of locations containing feral crustaceans	45	26	37	30
Number of locations containing only feral crustaceans	4	2	14	24
Number of new introduced crustacean species detected	1	<1	NA	NA

NA not applicable for this year of sampling



FRESHWATER BIOSECURITY FIGURE 1

2013 Freshwater Biosecurity Sampling Locations in Perth-metro region.

Indian Ocean Territories Fishery Status Report

S.J. Newman, L. Bellchambers, C. Skepper, S. Evans and D. Wallis

Main Features

Status		Current Landings	
Stock level	Some species at risk	Total	Not assessed
Fishing Level	Not Assessed	Main Commercial Fishery	Not reportable

Fishery Description

Commercial

In November 2002, the territorial seas (out to 12 nautical miles) of the Cocos (Keeling) Islands and Christmas Island were declared as 'excepted waters' from the *Fisheries Management Act 1991*. Management responsibilities were transferred from the Australian Fisheries Management Authority to the Commonwealth Government, and the Department of Fisheries of the Government of Western Australia has now taken on management responsibilities for the marine territorial waters of the Indian Ocean Territories on behalf of the Commonwealth Department of Infrastructure and Regional Development. The location of the Indian Ocean Territories and their proximity to the Western Australian coast are illustrated in Indian Ocean Territories Figure 1.

Under a Service Delivery Agreement with the Department of Infrastructure and Regional Development, the Department Fisheries, WA manages commercial, recreational and aquaculture activities at Cocos (Keeling) Islands and Christmas Island, in addition to providing fish health diagnostic services, biosecurity, fish pathology services and

licensing services. The Commonwealth Minister for the Department of Infrastructure and Regional Development currently holds responsibility for these excepted waters under the *Fish Resources Management Act 1994 (WA) (CI/CKI)* (the 'Applied Act').

The commercial Christmas Island Line Fishery (CILF) primarily targets pelagic species, mainly wahoo (*Acanthocybium solandri*) and yellowfin tuna (*Thunnus albacares*). In addition, demersal fishing activities are also undertaken targeting deepwater demersal fish, mainly the deepwater snappers.

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

Recreational

Large amounts of recreational fishing are undertaken around the Cocos (Keeling) Islands and Christmas Island targeting both finfish and invertebrate species. The Cocos (Keeling) Islands consist of a diverse range of fishable habitats that include a sheltered lagoon, fringing reefs and offshore 'blue water' environments that support a range of demersal and pelagic fish species, as well as various crustaceans (e.g. lobsters, crabs) and molluscs (e.g. gong gong, clams), which are highly sought after by fishers for both individual and community purposes. Christmas Island, on the other hand, has a limited amount of habitat available for fishing with no lagoon present, fringing reef surrounding the island and offshore 'blue water' environments that support pelagic fish species and a limited range of demersal fish species and some invertebrates (e.g. lobster, clams).

Governing legislation/fishing authority

Commercial

Fish Resources Management Act 1994 (WA) (CI/CKI) (the 'Applied Act')

Fish Resources Management Regulations 1995(WA) (CKI/CI) and subsidiary legislation

Fishing Boat Licenses with conditions

Cocos (Keeling) Islands Marine Aquarium Fish Fishery – Commonwealth Government *Environment Protection and Biodiversity Conservation Act 1999* (Export Exemption).

Recreational

Fish Resources Management Act 1994 (WA) (CI/CKI) (the 'Applied Act')

Fish Resources Management Regulations 1995 (WA) (CKI/CI) and subsidiary legislation.

Consultation processes

Commercial

Department–industry/community consultation – Christmas Island and Cocos (Keeling) Islands.

Recreational

Community Consultation - Cocos (Keeling) Islands and Christmas Island.

Boundaries

Commercial

The territorial seas around the Cocos (Keeling) Islands and Christmas Island (Indian Ocean Territories Figure 2 and 3).

Recreational

The territorial seas around the Cocos (Keeling) Islands and Christmas Island (Indian Ocean Territories Figure 2 and 3).

Management arrangements

Commercial

The Christmas Island Line Fishery (CILF) is managed primarily through input controls in the form of limited entry to the fishery and gear restrictions. Currently there are 3 licenses in the fishery, which all operated during 2013. The CILF also has output controls in the form of catch limits on both demersal and pelagic species to be harvested.

The commercial Cocos (Keeling) Islands Marine Aquarium Fish Fishery (CKIMAFF) is managed through input controls in the form of a limited entry fishery (there is only 1 licence in the fishery) and gear restrictions. The fishery also has a number of output controls in the form of limits on the species permitted to be harvested, limits on the total number of individuals of all species combined that can be harvested in a year and limits of the number of individuals within a Family that can be harvested within a year. Data for this fishery cannot be reported due to confidentiality limitations (i.e. there is only one licence in the fishery).

Recreational

Island-specific recreational fisheries management arrangements for the Indian Ocean Territories are currently being progressed to legislation.

Research summary

A risk assessment workshop was undertaken in 2011 to refine fisheries management and research priorities at the Indian Ocean Territories. Finfish fisheries research has focused on undertaking visual census surveys of shallow reef fish assemblages, trialling baited remote underwater video systems and collecting biological material from a suite of species at the Cocos (Keeling) Islands and Christmas Island to examine their connectivity with other sites along the Western Australian coast and locations in the wider Indo-Pacific. The finfish group has also been working on collating all historical research data on fish assemblages at the IOTs. A report is in preparation. The marine ecology and monitoring section has focussed on invertebrate and ecosystem research at the Cocos (Keeling) Islands. Invertebrate research has focussed on assessments of the abundance and biology of the key recreational invertebrate species of gong gong (*Lambis lambis*) and giant clams (*Tridacna* spp.). Previous surveys have also examined the abundance and distribution of bêche-de-mer (Holothurians). Ecosystem research has focussed on maintaining a long term reef-monitoring program at Cocos (Keeling) Islands to help detect changes to the benthic reef and lagoon environments and associated targeted recreational fish species using stereo diver operated videos (DOVs) and baited remote underwater videos (BRUVs).

Retained Species

Commercial landings (season 2013) 6.7 tonnes

Pelagic species dominate the catch of the CILF, comprising 91% (6.1 t) of the total reported catch. Wahoo (*Acanthocybium solandri*) is the main target species of the CILF, comprising 70% (4.7 t) of the total reported catch. Other pelagic species are also targeted during the trolling operations and primarily include yellowfin tuna (*Thunnus albacares*) and other tunas (except southern bluefin tuna *(Thunnus maccoyii)*, and dogtooth tuna *(Gymnosarda unicolor)*, which may not be taken), and to a lesser extent mahi mahi (*Coryphaena* spp.). Some commercial fishing activities are also undertaken for demersal fish species, mainly deep slope species such as ruby snapper (*Etelis* spp.) and these species comprised 9% (0.6 t) of the total reported catch in 2013. The commercial catch for Christmas Island usually consists of catch data from only 2 vessels and the exact catch data in many years is not reportable due to confidentiality provisions. The total reported catch for this fishery has been less than 10 tonnes per annum over the last 8 years.

There is no commercial line fishery at the Cocos (Keeling) Islands.

The CKIMAFF targets the endemic Cocos Angelfish or Yellowheaded Angelfish (*Centropyge joculator*), and to a lesser extent the lemonpeel angelfish (*Centropyge flavissima*). As there is only one license in the CKIMAFF the catch data is not reportable due to confidentiality provisions.

Recreational catch estimate (season 2013)

Not assessed

Recreational fishing vessels operate around the Cocos (Keeling) Islands and Christmas Island. The amount and magnitude of the recreational fishing catch and effort at these islands has not been assessed. Island-specific recreational bag limits, area closures, and gear restrictions are currently being progressed.

Fishing effort/access level

Commercial

Effort in the CILF has been increasing steadily over the past five years, with 252 fishing days reported in 2013. Effort in the fishery is weather dependent and is limited by access to the water through the principal boat ramp at Flying Fish Cove, and to a lesser extent the Ethel Beach boat ramp.

Effort in the CKIMAFF has been similar over the last few years providing a similar level of catch.

Recreational

Effort by recreational anglers at both the Cocos (Keeling) Islands and Christmas Island is weather dependent. At the Cocos (Keeling) Islands the prevailing weather conditions determine what part of the Island complex is subject to fishing activities. Access to the water at Christmas Island is limited to the principal boat ramp at Flying Fish Cove, and to a lesser extent the Ethel Beach boat ramp.

Stock Assessment

Assessment complete: Yes

Assessment method: Risk Assessment

Breeding stock level: Some species at risk

Invertebrates:

Holuthurians: In 2006 a large-scale assessment of the holothurian communities inhabiting the lagoon and outer reef at the Cocos (Keeling) Islands was undertaken to determine the status of key holothurian species and enable recommendations to be made regarding the feasibility of a commercial holothurian fishery being developed in the region. Analysis of abundance and distribution data found that the holothurian community is strongly influenced by habitat and although some species are wide-ranging and found in relatively high densities, they tend to be of low economic value. In contrast, species of moderate to high value were recorded at densities too low to support commercial fisheries and typically had very restricted distributions. The holothurian community found at the Cocos (Keeling) Islands is near to pristine, due to a lack of historical fishing pressure. Holothurian stocks are very sensitive to fishing pressure and have been heavily overexploited in other areas of the Indian and Pacific Oceans.

Gong Gong: The common spider conch or gong gong (*Lambis lambis*) is a heavily recreationally-targeted gastropod inhabiting shallow waters of the lagoon. This species is vulnerable to over-fishing as it is highly accessible and presumably shares biological traits with other exploited conch species, including slow growth and late maturity. Monitoring data collected between 2007 and 2014 indicates that the current abundance of gong gong is lower than recorded historically. While heavy fishing pressure has presumably contributed to the reduction in gong gong numbers, further monitoring is required to determine the role of recruitment variability in maintaining gong gong populations at the Cocos (Keeling) Islands and changes in the lagoon system.

Giant Clams and Coral: The sustainability of giant clam (*Tridacna* spp.) and coral species were identified as potential concerns during recent risk assessments undertaken for the marine resources of the Cocos (Keeling) Islands by the Department of Fisheries, WA. To address these concerns, a stock abundance and distribution assessment of giant clams was undertaken in 2011/12. In addition, an on-going reef monitoring program has been established to monitor natural and anthropogenic impacts on the reef and lagoon communities at Cocos (Keeling) Islands.

The implementation and ongoing monitoring of these initiatives will enable the Department of Fisheries, WA to assess the health of the invertebrate stocks and reef and lagoon ecosystems at the Cocos (Keeling) Islands to effectively detect change, both spatially and temporally, resulting in better management of the natural resources of the Atoll.

Finfish:

Data on the abundance of finfish species is being collected and collated to determine changes over time. A number of recent surveys have been undertaken at both localities

(Hobbs, pers. comm., DoF). Some species appear to have exhibited marked declines in abundance. For example, Lincoln Smith *et al*. (1995)[1] reported that the squaretail coral trout (*Plectropomus areolatus*) was abundant on shallow reefs (<10m) and was one of the species most commonly recorded on deep reefs (15-20m). Cocos Malay community members have advised that recreational fishers in the waters of the lagoon targeted these species using lines. This species is now extremely low in abundance at the Cocos (Keeling) Islands (Hobbs, Choat pers. comm.), suggesting local depletion and/or overexploitation of the stock.

The pelagic species that are targeted by the CILF (e.g. wahoo, yellowfin tuna) are likely to be part of a wider Indian Ocean stock. However, the demersal species are likely to be localised stocks that are reliant upon self-recruitment.

There is anecdotal evidence of localised depletion of some deep slope species like rosy snapper (*Pristipomoides filamentosus*) and ruby snapper (*Etelis carbunculus*) around Christmas Island. An increasing number of recreational fishers are using electric-powered lines to target deep-slope demersal finfish species at the Indian Ocean Territories, thereby increasing the effective fishing effort for these species.

It is hoped that the introduction of recreational fishing rules at the Indian Ocean Territories will assist in reducing the sustainability risks identified.

Aquarium Fish:

The CKIMAFF targets *Centropyge joculator* and to a lesser extent *Centropyge flavissima. Centropyge joculator* is endemic to the Cocos and Christmas Islands and inhabits fringing reefs from 15 to 70 m.

Little is known about the biology of *C. joculator* although Allen *et al*. (2007)[2] describe this species as being abundant on Christmas Island.

Non-Retained Species

Bycatch species impact: **Negligible**

Fishing in the CILF for pelagic species such as wahoo uses specialised trolling gear to target the fish and involves limited discarding. Species occasionally caught and sometimes retained but generally discarded include billfish, barracuda, shark and trevally. A high proportion of the above species are expected to survive capture and release by the fishery. Consequently, it is considered likely that the pelagic fishery has a negligible impact on stocks of discarded species.

Fishing for demersal species in the CILF particularly those in the deep slope waters involves limited discarding as most species are retained for processing. However, catches can be lost to sharks.

The fishing techniques used to capture fish in the CKIMAFF involve using hand or scoop nets, or a small seine net of specific dimensions (the seine net cannot exceed 16 metres in length, must have a mesh of less than or equal to 28mm and a drop of not more than 3 metres) and may use SCUBA equipment. Thus, the CKIMAFF has negligible bycatch due to the highly selective nature of fishing activities.

Listed species interaction: **Negligible**

The line fishing methods used in CILF are not known to catch any listed species. However, there is some potential for low levels of seabird bycatch at Christmas Island.

No listed species interactions have been reported for the CKIMAFF.

Ecosystem Effects

Food chain effects: **Not assessed**

Habitat effects: **Negligible**

The line fishing methods used in the CILF and the hand collection method used in the CKIMAFF are likely to have minimal impact on the habitat.

Social Effects

Commercial

At least 4 people were employed in the CILF around Christmas Island during 2013. This estimate is based on the number of vessels reporting catches and the average number of crew on each boat.

At least 2 people were employed in the CKIMAFF around Cocos (Keeling) Islands during 2013.

Recreational

Due to their sport fishing and eating qualities, wahoo and other pelagic species are popular target species for recreational anglers and fishing charter operators at the Indian Ocean Territories, particularly at Christmas Island. They are usually captured from small boats, although shore-based fishing is also undertaken.

A large variety of demersal and lagoon finfish and invertebrate species are caught by recreational fishers at Cocos (Keeling) Islands involving the use of a large number of small vessels. Similarly, recreational fishers at Christmas Island undertake fishing activities from a number of small vessels and also fishing from the shore and catch a large variety of demersal finfish species including a large number of deep slope species.

Economic Effects

Estimated annual value (to fishers) for 2013:

Not assessed

The value of the CILF is not known. The value of the CKIMAFF is also unknown, although *C. joculator* commands a high price on the international market (reported in excess of AUS $700.00 each).

1 Lincoln-Smith, M.P., Skilleter, G.A., Underwood, A.J., Stark, J., Smith, A.K., Hawes, P.M.H, Howitt, L., White, G.A. and Chapman, M.G. 1995. Cocos (Keeling) Islands: Quantitative baseline surveys for core marine reserves and biosphere reserve in the South Keeling lagoon (prepared for Australian Nature Conservation Agency Project 153). The Institute of Marine Ecology, University of Sydney and The Ecology Lab Pty. Ltd., Sydney, Australia.

2 Allen, G.R., Steene, R.C. and Orchard, M. 2007. Fishes of Christmas Island (Second Edition). Christmas Island Natural History Association, Christmas Island, Indian Ocean, Australia. 284 pp.

Fishery Governance

Commercial
Target commercial catch range: Not available

Current Fishing (or Effort) Level: Not assessed

The potential recreational fishing effort for both pelagic and demersal fish species at both the Cocos (Keeling) Islands and at Christmas Island is high with a capacity to operate over the entire extent of the fishable area at each island group. Given the restricted amount of habitat and fishing area available it is expected that fishing pressure on some species at Cocos (Keeling) Islands or Christmas Island is above sustainable levels.

The catch of the CKIMAFF has been small since its inception in 1993. There is little incentive for the single licensee to increase catch or effort since market viability and high prices are maintained by only having small numbers of fish available for sale.

New management initiatives (2014)

New island-specific recreational fisheries management arrangements for the Indian Ocean Territories are currently being progressed to legislation.

The effective implementation of any future recreational fisheries management legislation at the Indian Ocean Territories will require ongoing community education and compliance programs.

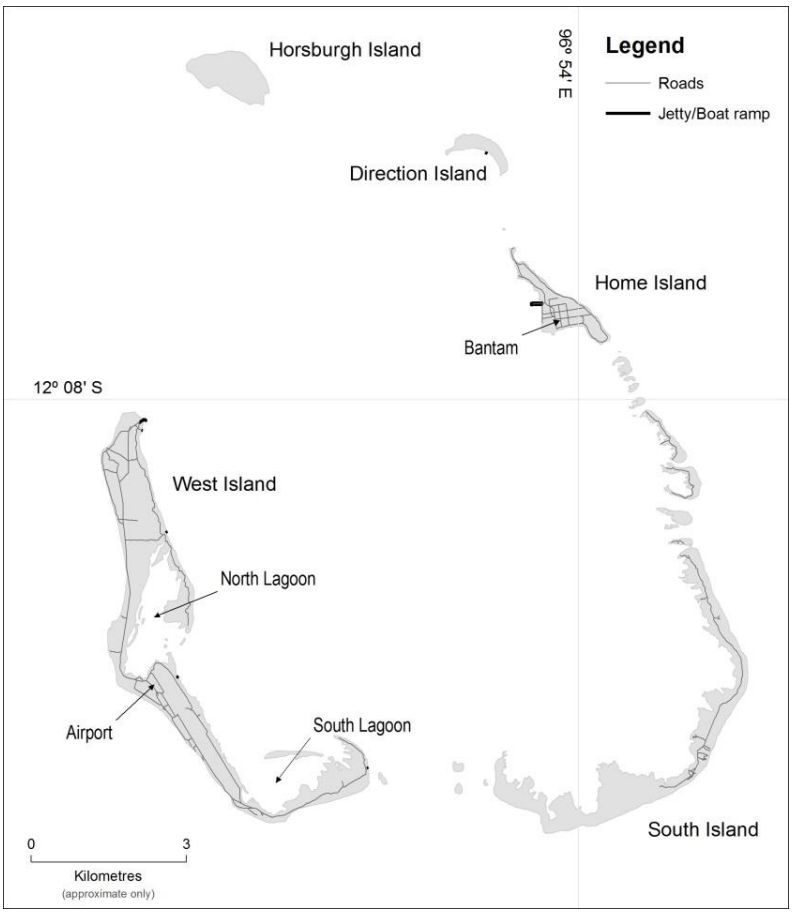
External Factors

The demersal fish and invertebrate populations of Cocos (Keeling) Islands and Christmas Island are likely to consist of small, isolated populations that are expected to experience highly variable recruitment due to environmental fluctuations.

In February 2012, the MV Tycoon was grounded in Flying Fish cove on Christmas Island spilling phosphate and fuel oils into the Cove and surrounding areas. Assessment of the impacts of the MV Tycoon grounding on fish assemblages and reef habitats has not been finalised.

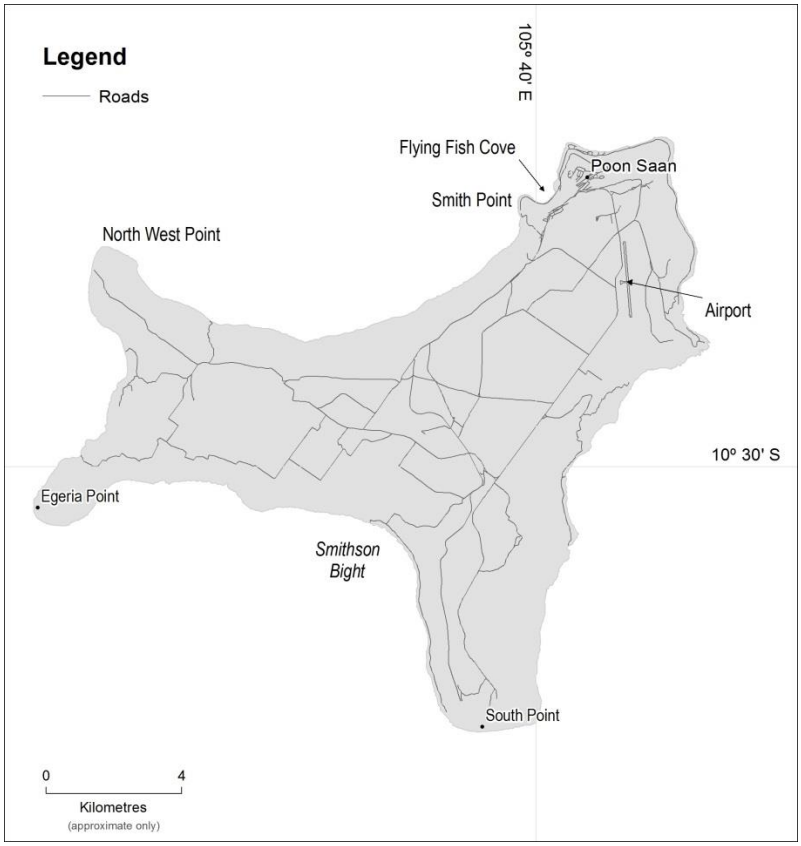
INDIAN OCEAN TERRITORIES FIGURE 1

Location of the Cocos (Keeling) Islands and Christmas Island comprising the Indian Ocean Territories within the Indian Ocean and illustrating their proximity to the Western Australian coast.



INDIAN OCEAN TERRITORIES FIGURE 2

Location of the major Islands and landmarks within the Cocos (Keeling) Islands in the Indian Ocean.



INDIAN OCEAN TERRITORIES FIGURE 3

Location of the key landmarks around Christmas Island in the Indian Ocean.

Finfish Ageing Laboratory

J. Norriss

The Finfish Ageing Laboratory (FAL) at the WA Fisheries and Marine Laboratory continues to produce age data for assessing stocks of indicator finfish species in Western Australian. Age demographics, recruitment patterns, growth rates, age at onset of sexual maturity and/or sex change, and longevity are all critical parameters for assessing the status of fish stocks.

Estimating the age of a fish is a routine procedure accomplished by removing the otoliths (ear stones) and interpreting their alternating opaque and translucent zones deposited throughout the lifetime of the fish, similar to growth rings in a tree. Interpretation usually requires the otolith be sectioned and mounted on a microscope slide.

The priority species for the FAL are set by the Resource Assessment Framework (RAF) for Finfish Resources (Department of Fisheries WA, 2011)[1]. It identifies the most important (indicator) species for a range of ecological suites across the four marine Bioregions, ranked in terms of their risk to sustainability. The RAF is subject to periodic review.

In 2013 the FAL processed and aged 18,098 fish (see Finfish Ageing Laboratory Table 1), the highest annual total on record. The priority species were barramundi, red emperor and goldband snapper from the North Coast Bioregion, (pink) snapper from the Gascoyne Bioregion, Australian herring, West Australian dhufish, (pink) snapper, redthroat emperor and Bight redfish from the West Coast Bioregion, and cobbler, (pink) snapper and Bight redfish from the South Coast Bioregion.

The number of fish aged in 2013 was significantly higher than the ~11,500 fish aged in 2012. This was due to more species that could be aged using whole rather than sectioned otoliths (e.g. Australian herring and cobbler) and additional staff.

The FAL is working with fisheries agencies around Australia, under the auspices of the Australian Society for Fish Biology's committee for the National Framework for Routine Fish Ageing, to develop best practice protocols (guidelines) for the production of quality-assured fish age data for stock assessments of Australian fisheries. Outcomes will be documented as national best practice standards, guidelines, or protocols that can be developed on an agency and species-specific basis. The document is planned to be completed in 2015.

Meanwhile, a guide to methods used to age key finfish species from the West Coast and South Coast Bioregions is currently being developed by the Department of Fisheries, with a combined North Coast and Gascoyne Coast Bioregions guide to follow. There will be a chapter devoted to each key species, authored by scientists experienced in interpreting their otoliths and routinely generating age estimates. The Australian herring chapter will be the first to be developed and will serve as a template for other chapters.

FINFISH AGEING LABORATORY TABLE 1.

The number of fish processed and aged by the Finfish Ageing Laboratory in 2013, by Bioregion, species, ecological suite and whether it is and indicator species for that suite.

North Coast Bioregion	Number processed	Ecological suite	Indicator species
Barramundi *Lates calcarifer*	473	Estuarine	Yes
Rusty jobfish *Aphareus rutilans*	63	Inshore demersal	No
Goldband jobfish *Pristpomodides multidens*	739	Inshore demersal	Yes
Red emperor *Lutjanus sebae*	598	Inshore demersal	Yes
Total	1,873		

Gascoyne Bioregion	Number processed	Ecological suite	Indicator species
Pink snapper *Chysophrys auratus*	1,081	Inshore demersal	Yes
Spangled Emperor *Lethrinus nebulosus*	232	Inshore demersal	Yes
Total	1,313		

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

West Coast Bioregion	Number processed	Ecological suite	Indicator species
Black bream *Acanthopagrus butcheri*	2	Estuarine	yes
Australian herring *Arripis georgianus*	2,164	Nearshore	Yes
Southern garfish *Hyporhamphus melanochir*	1,284	Nearshore	No
West Australian Dhufish *Glaucosoma hebraicum*	1,527	Inshore demersal	Yes
Pink Snapper *Pagrus auratus*	2,293	Inshore demersal	Yes
Redthroat emperor *Lethrinus miniatus*	2,005	Inshore demersal	Yes
Bight Redfish *Centroberyx gerrardi*	1,821	Inshore demersal	Yes
Total	11,096		

South Coast Bioregion	Number processed	Ecological suite	Indicator species
Cobbler *Cnidoglanis macrocephalus*	960	Estuarine	Yes
Pink Snapper *Pagrus auratus*	825	Offshore demersal	Yes
Bight Redfish *Centroberyx gerrardi*	1,779	Offshore demersal	Yes
Total	3,564		

Statewide	Number processed	Ecological suite	Indicator species
Eightbar Grouper *Hyporthodus octofasciatus*	21	Not assessed	Yes
Bass Groper *Polyprion americanus*	13	Not assessed	Yes
Hapuku *Polyprion oxygenios*	75	Inshore demersal	Yes
Blue Eye Trevalla *Hyperoglyphe antarctica*	35	Not assessed	Yes
Ruby snapper *Etelis carbunculus*	72	Offshore demersal	Yes
Etelis marshi	35	Not assessed	No
Knifejaw *Oplegnathus woodwardi*	1	Inshore demersal	No
Total	252		

GRAND TOTAL	18,098

APPENDIX 4

Annual performance for commercial fisheries subject to export approval under the Commonwealth Government's Environment Protection and Biodiversity Conservation Act 1999

The following table provides a summary of the issues, performance measures and any conditions for fisheries subject to the above Act and their annual performance. The period assessed in each case is the most recent season for which complete data are available. As a result of the duration required for data collection and analysis, the years being assessed in this volume are the 2012/13 season or the calendar year 2013 for fisheries data but up to June 2014 for relevant research or management actions projects and actions.

In addition to this summary, more detailed information on the annual performance of each fishery is provided in the relevant status reports presented throughout this volume. Within the individual status reports, each performance measure assessed is shown in a highlighted box to assist the reader.

It should also be noted that where naturally occurring fluctuations in fish stocks have required management adjustments or where improvements have been made to methods of analysis, these have in some cases (asterisked) required a revision of the performance measure this year.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: Abalone *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* August 2004 *Current accreditation:* August 2009 *Expiry date:* September 2014	Greenlip/brownlip abalone Areas 2/3 (spawning stock)	Effort range 907–1,339 diver days; minimum meat weight 140 g greenlip, 160 g brownlip	Acceptable	
	Roe's abalone Area 1 (spawning stock)	Effort range 14–43 diver days; total catch 9.9 t	Acceptable	Exploratory quota. No fishing in 2012/2013.
	Roe's abalone Area 2 (spawning stock)	Effort range 80–106 diver days; total catch 19.8 t	Acceptable	Total catch indicator only met in the Area 2 fishery. This is due to poor economic and weather conditions.
	Roe's abalone Area 5 (spawning stock)	Effort range 100–140 diver days; total catch 20 t	Acceptable	
	Roe's abalone Area 6 (spawning stock)	Effort range 80–127 diver days; total catch 12 t	Acceptable	
	Roe's abalone Area 7 (spawning stock)	Effort range 175–215 diver days; total catch 36 t	Acceptable	Area 8 fishery closed to fishing due to environmentally induced mass mortality
	Roe's abalone Area 8 (spawning stock)	Effort range 140–200 diver days; total catch 12t	Acceptable	
Fishery: Abrolhos Islands and Mid West Trawl *Approval type:* Accredited Export Exempt Fishery *Initial accreditation*: March 2005 *Current accreditation:* March 2013 *Expiry date*: March 2018	Scallops (spawning stock)	The residual stock index determines a predicted catch that sets the length of the next season and the fishing season ceases at a catch rate threshold level,	Inadequate	The survey catch prediction was below the target range therefore the fishery did not open in 2012 due to low stock levels

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: Beche-de-mer *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* December 2004 *Current accreditation:* August 2011 *Expiry date*: August 2015	Beche-de-mer species (spawning stock)	Sandfish acceptable catch range: 20-100 t. Catch rate above 25 kg/hr. Redfish acceptable catch range: 40-100 t. Catch rate above 60 kg/hr.	Acceptable	Only sandfish assessed. No fishing for Redfish occurred in 2012.
Fishery: Broome Prawn *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* August 2004 *Current accreditation:* August 2010 *Expiry date:* August 2015	Western king prawn (spawning stock)	Annual exploitation rate of king prawns to not exceed 60% in any one year	Acceptable	Very low level of effort this year.
	Coral prawns (spawning stock)	Total catch within acceptable range of 20–90 t (7-year catch range)	Acceptable	Low level of exploitation
Fishery: Exmouth Gulf Prawn *Approval Type:* Accredited Export Exempt Fishery *Initial accreditation:* March 2003 *Current accreditation:* February 2013 *Expiry date*: February 2018	Tiger prawn (spawning stock)	Catch rate above 25 kg/hr (6 fathom quad gear) revised from original 8–10 kg/hr (7.5 fathom twin gear)	Acceptable	Catch rate below target level but above the limit due to adverse environmental conditions and now rebuilding.
	King prawn (spawning stock)	Total catch within acceptable range of 350–500 t	Acceptable	Below range due but the catch prediction was low and landings were within the prediction range with a conservative harvesting strategy
	Endeavour prawn (spawning stock)	Total catch within acceptable range of 120–300 t	Acceptable	Low effort as its distribution overlaps that of tiger prawns.
	Banana prawn (spawning stock)	Total catch within acceptable range of 10–60 t for years with significant rainfall and 0–2 t for years with low rainfall	Acceptable	
	Coral prawns (spawning stock)	Total catch within acceptable range of 20–100 t	Acceptable	Low effort and value resulted In low retention rates
	Non –Retained species	The major species of bycatch are found in significant numbers outside of the trawled areas	Acceptable	
	Impact to mud/shell (habitat)	< 40% of mud/shell habitat in Exmouth Gulf trawled	Acceptable	

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: Gascoyne Demersal Scalefish Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* June 2004 *Current accreditation:* August 2010 *Expiry date*: September 2015	Pink snapper (spawning stock)	Catch rate not to fall below 500 kg/standard June–July boat day	Acceptable	The performance measure needs to be reviewed following significant reductions in quota and the move (in 2008) to higher resolution catch & effort reporting (daily/trip logbooks).
Fishery: Kimberley Prawn *Approval Type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* August 2010 *Expiry date*: August 2015	Banana prawn (spawning stock)	Total catch within acceptable range of 200–450 t	Acceptable	
	Brown tiger prawn (spawning stock)	Total catch within acceptable range of 15–60 t	Acceptable	Low landings due to low effort and targeting on high catch rates of banana prawns.
	Endeavour prawn (spawning stock)	Total catch within acceptable range of 7–80 t	Acceptable	As above
	Coral prawns (spawning stock)	Total catch within acceptable range of 0–6 tonnes (10-year catch range)	Acceptable	As above
	Black tiger prawn (spawning stock)	Total catch within acceptable range of 0–1 t	Acceptable	
	Squid (spawning stock)	Total catch within acceptable range of 1–50 t	Acceptable	Nil reported landings since 2004.
Fishery: Mackerel *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* November 2009 *Expiry date*: November 2014	Spanish mackerel (spawning stock)	Total catch within acceptable range of 246-410 t: acceptable regional catch ranges: Kimberley 110–205 t: Pilbara 80–126 t: Gascoyne/West Coast 56–79 t	Acceptable	
Fishery: Marine Aquarium Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* October 2005 *Current accreditation:* December 2013 *Expiry date*: October 2016	Seahorses of hippocampus species/coral/giant clam	No export of Hippocampus spp. but managed to limit of 2000 for domestic purposes	Acceptable	

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: Northern Demersal Scalefish *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* June 2010 *Expiry date*: June 2015	Red emperor and goldband snapper (spawning stock)	Spawning biomass > 40% of virgin spawning biomass with lower limit of 30%; total annual catches should not increase > 20% above average catches of previous 4 years; no decrease in annual trap catch rates in 2 consecutive years	Acceptable	
	Cods/groupers (spawning stock)	Total annual catch should not increase >20% above average catch of previous 4 years; no decrease in annual trap catch rates in 2 consecutive years.	Acceptable	
Fishery: Onslow and Nickol Bay Prawn *Approval Type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* August 2010 *Expiry date*: August 2015	Banana prawns (spawning stock)	Nickol Bay: total catch in high rainfall years within acceptable range of 40–220 t: in low rainfall years within acceptable range of 0–40 t.	Acceptable	
		Onslow: total catch within acceptable range of 2–90 t	Acceptable	No fishing undertaken In 2012.
	Brown tiger prawn (spawning stock)*	Acceptable catch ranges of Nickol Bay 2–40 t and Onslow 10–120 t	Acceptable	Below target in Nickol Bay due to low effort and targeting on high catch rates of banana prawns and fleet transfer to other trawl fisheries.
	Western king prawn (spawning stock)	Acceptable catch ranges of Nickol Bay 20–70 t and Onslow 10–55 t	Acceptable	Below target due to low effort in Nickol Bay. No fishing Iin Onslow.
	Endeavour prawn (spawning stock)	Total catch within acceptable ranges; Nickol Bay 1-10 t and Onslow 5-20 t.	Acceptable	As above
	Coral prawns (spawning stock)	Total catch within acceptable range of Nickol Bay 1–15 t (10-year catch range) and Onslow 4–20 t	Acceptable	As above
	Black tiger prawn (spawning stock)	Total catch within acceptable range of 0–2 t	Acceptable	
Fishery: Pearl Oyster *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* September 2003 *Current accreditation:* December 2013 *Expiry date*: December 2018	Silver-lipped (gold-lipped) pearl oyster (spawning stock)	Fished area should be < 60% of species distribution; catch rates should not decrease by > 50% from historical averages of 29.5 oysters/hr (Zone 2) and 34.8 oysters/hr (Zone 3); > 30% of Zone 1 catch should be > 150 mm shell length	Acceptable	Catch rates have returned to normal levels after some years of high catch rates due to high recruitment.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: Pilbara Trawl *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* November 2004 *Current accreditation:* May 2014 *Expiry date*: May 2017	Long-lived target species (spawning stock) – includes Rankin cod, red emperor, scarlet perch, goldband snapper, red snapper, spangled emperor	Spawning biomass of Rankin cod and red emperor should remain above minimum limit of 40% of virgin spawning biomass; annual trawl catch should not increase > 20% above average catch of previous 4 years; no decrease in annual trawl catch rates in > 2 consecutive years	Acceptable	
	Short-lived target species (spawning stock)	Median spawning biomass of blue-spot emperor should be > 40% of the 1993 spawning biomass in Area 1; annual catch of each short-lived target species should not increase > 20% above the average annual catch of the previous 4 years; annual catch rate of each short-lived target species should not decrease in two consecutive years	Acceptable	
	Bycatch of listed species - dolphins	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Dolphin mortalities reported in statutory logbooks have reduced to less than 25 per year since 2006
	Bycatch of listed species – turtles	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Mitigation devices implemented in nets in 2006 reduce the incidental captures of turtles by 97%
	Bycatch of listed species – syngnathids	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Number of pipefish caught and released alive should be < 500/yr; number of seahorses caught and released alive should be < 60/yr;
	Bycatch of listed species – sawfish	All skippers to maintain records of the time, date, shot duration and location of each incidental capture	Acceptable	Number of sawfish caught should be < 120/yr; number of sawfish released alive should be increased to 50% of captures by 2008

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
	General ecosystem – large epibenthos	The total area of the Pilbara demersal fish fishery (encompassing both trawl and trap fisheries) that is closed to trawling is 80%; the total area of the Pilbara demersal fish fishery between depths of 30 m and 120 m should remain at or below the current level of 60%	Acceptable	
Fishery: Salmon *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* November 2009 *Expiry date*: November 2014	Western Australian salmon (spawning stock)	Expected catch range under the current management regime is 1,200–2,800 t	Acceptable	2012 catch below target range due to the combined effects of lack of targeting due to weak market demand, low catchability due to environmental factors (relatively high water temperatures) and low availability of fish due to recruitment variation. Stock level considered adequate.
Fishery: Shark Bay Crab Interim Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* November 2004 *Current accreditation:* October 2011 *Expiry date*: September 2016	Blue swimmer crab (breeding stock)	CPUE to remain above 1 kg/trap lift	Inadequate:	Voluntary commercial closure since April 2012. as a result of low abundance from June 2011 due to the marine heatwave event over the 2010/11 summer.
Fishery: Shark Bay Prawn *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* February 2003 *Current accreditation:* January 2013 *Expiry date*: February 2018	Tiger prawn (spawning stock)	Level of spawning stock present based on fishery independent surveys during the spawning season to be between 25-30 kg/hr (5.5 fathom quad gear	Acceptable	The spawning stock was well below target however recruitment lin 2013 indicated no recruitment failure. The area assessed as the key spawning area is being reviewed.
	King prawn (spawning stock)	Total catch within historical acceptable range of 1,100–1,600 t, given no change in effort	Acceptable	Slightly below the historical range but within the new range set to account for reduced effort.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
	Coral and endeavour prawns (spawning stock)	Total catch within historical acceptable ranges given no change in effort: coral 80–280 t, endeavour 1–30 t	Acceptable	
	Loggerhead turtles (captures)	90% of turtles captured from non-BRD nets returned alive	Acceptable	BRDs are mandatory in all nets so this performance measure is no longer valid. For the 2012 season, 6 turtles were recorded as caught in nets and all were recorded as being returned to the sea alive.
	Discarded fish (abundance)		Acceptable	Majority of bycatch species are found in relatively significant numbers outside of trawled areas
	Impact to sand/shell (habitat)	< 40% of sand/shell habitat in Shark Bay trawled	Acceptable	
	Impact to coral/sponge (habitat)	<20% of the remaining coral/sponge habitat in Shark Bay to be contained within the legally trawled area	Acceptable	
	Discarding fish (provisioning)		Acceptable	Reduction in amount of discards and ratio of discards to target catch from pre-catch reduction device levels and in water hopper system increasing survival of some bycatch species.
Fishery: Shark Bay Scallop *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* February 2003 *Current accreditation:* January 2013 *Expiry date*: January 2018	Scallop (spawning stock)	Monitoring of recruits/ residual stock to ensure the start date of the season is set so that there is adequate level of breeding stock present when spawning commences	Inadequate.	Catch prediction below target level due to poor environmental conditions and the fishery did not open.
	Loggerhead turtles (captures)	90% of turtles captured from non-BRD nets returned alive	Acceptable	No fishing effort in 2012.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: South Coast Crustacean *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* September 2004 *Current accreditation:* November 2011 *Expiry date*: Mid-2015	Southern rock lobster (spawning stock)	Catch to remain between 50 to 80 tonnes	Acceptable	New management arrangements for south coast crustacean fisheries should be finalised in 2015.
Fishery: Specimen Shell *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* 25 May 2005 *Current accreditation:* December 2013 *Expiry date*: May 2015	Specimen shell species (spawning stock)	Preliminary acceptable catch range is from 10,000–25,000 shells; acceptable catch rate 10–40 shells per day	Not assessed	Both catch and catch rate within acceptable ranges
Fishery: Temperate Demersal Gillnet and Demersal Longline (Shark) Fisheries *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* February 2006 *Current accreditation:* March 2012 *Expiry date*: August 2015	Dusky and sandbar sharks	Continue to review and report outcomes of actions taken to rebuild stocks	On-going	Recovery of dusky sharks is clearly evident and sandbar sharks is now likely. New stock assessments due in mid 2015
	Dusky and sandbar sharks	Continue to develop strategies to ensure recovery of stocks within biologically appropriate timeframes	Underway	Draft strategies developed as part of the MSC pre-assessment processes
	Australian sea lions	Continue monitoring fishing effort around Australian sea lion colonies and investigate and implement management measures that will limit the overlap of gillnet fishing and Australian sea lion foraging areas to support recovery of the species. These management measures could include independent validation of interaction rates	Underway and ongoing	An ASL working Group is exploring the potential of (electronic) observer programs within the fishery. The Working Group is also undertaking activities to monitor spatio-temporal levels of gillnet effort and to develop an annual risk assessment. The Department Is also supporting further research on ASL foraging ranges being undertaken within an Australian Marine Mammal Centre research project.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2012/13 or 2013	Comment
Fishery: West Coast Rock Lobster *Approval Type:* Wildlife Trade Operation Exemption *Initial accreditation:* August 2002 *Current accreditation:* May 2013 *Expiry date*: May 2015	Western rock lobster (spawning stock)	Spawning biomass at Abrolhos Islands and coastal regions to remain above respective levels during the early 1980s with 75% certainty	Acceptable	
	Octopus (spawning stock)	Catch rate not to drop outside of historic range by > 10%	Un-acceptable	
	Sea lion (captures)	No increase in rate of capture	Acceptable	No sea lion captures were reported
	Leatherback turtle (entanglements)	No increase in rate of interactions	Acceptable	No entanglements were reported
	Whales and dolphins (entanglements)	No increase in rate of interactions	Un-acceptable	There were 18 confirmed whale entanglements in WRL gear during the 2013 humpback whale migration season. Mitigation measures have been implemented to reduce whale entanglements.
Fishery: West Coast Deep Sea Crustacean Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* March 2004 *Current accreditation:* May 2013 *Expiry date*: May 2018	Champagne and Giant crab (spawning stock)	Unitisation of the fishery has permitted a maximum of 14t of Champagne crab and Giant crab to be taken in a season	Acceptable	
	Crystal Crab (spawning stock)	The fishery is quota based with catches limited to 140t of crystal crab per season	Acceptable	

APPENDIX 5
Fisheries Research Division staff adjunct positions and supervision of students

Staff Member	Position
David Abdo	Adjunct Lecturer, Faculty of Natural and Agricultural Sciences , University of Western Australia
	PhD co-supervision, Murdoch University, supervises Daniel Yeoh – "Ecology and movement patterns of the fish fauna in the Walpole-Nornalup Marine Park".
Lynda Bellchambers	Adjunct Researcher, Faculty of Natural and Agricultural Sciences , University of Western Australia
	PhD co- supervision, University of Western Australia, supervises Luke Thomas - 'Coral recruitment on a high latitude remote reef system.'
Matias Braccini	PhD co-supervision, Universidad de Mar del Plata, Argentina, supervises Marcelo Perez – 'Patrones de desplazamiento del gatuzo (*Mustelus schmitti*) en el Ecosistema Costero Bonaerense a partir de la técnica de marcación con marcas convencionales. Implicancias para el manejo y explotación del recurso' (in Spanish).
	Honours co-supervision, University of Western Australia, supervises Matt Navarro - " Trends in abundance and management of vulnerable chondrichthyans to the effects of deep-sea fishing"
	Honours co-supervision, University of Western Australia, supervises Shelby Oliver- " Global patterns of chondrichthyan bycatch in commercial fisheries "
Samantha Bridgwood	Technical Advisor for IMarEST Biofouling Expert Management Group
Dave Fairclough	Adjunct Senior Lecturer (May 2014-April 2017). School of Veterinary and Life Sciences, Murdoch University.
	Adjunct Senior Lecturer (March 2014-December 2015). Department of Environment and Agriculture, Faculty of Science and Engineering. Curtin University.
Rick Fletcher	Member and Acting Chair, NSW Marine Estate Expert Knowledge Panel
Norman Hall	Emeritus Professor, Murdoch University
	Scientific member of Northern Prawn Resource Assessment Group (NPRAG)
	Supervision, Calais Tink - Use of surveys and agent-based modelling to assess the management implications of the behaviours of specialised recreational boat fishers. PhD, Murdoch University
	Supervision, Alan Cottingham - Variations in the life-history characteristics of Black Bream *Acanthopagrus butcheri* in south-western Australia. PhD, Murdoch University
	Supervision, Eloïse Ashworth - Influence of environmental variables on the growth and reproductive biology of Black Bream, *Acanthopagrus butcheri*
	Supervision, Daniel Yeoh – Gillnet selectivity of Black Bream *Acanthopagrus butcheri*, Honours, Murdoch University
Alastair Harry	Adjunct Research Associate, School of Earth & Environmental Sciences, James Cook University
Alex Hesp	Adjunct Senior Lecturer, Murdoch University
	Co-supervision Calais Tink. Use of surveys and agent-based modelling to assess the management implications of the behaviours of specialised recreational boat fishers. PhD, Murdoch University.
	Co-supervision Alan Cottingham. Variations in the life-history characteristics of Black Bream *Acanthopagrus butcheri* in south-western Australia. PhD, Murdoch University.
Craig Lawrence	Adjunct Associate Professor, The University of Western Australia
	PhD supervision Miriam Sullivan- Fishing for Answers: How can we improve welfare for aquarium fish? The University of Western Australia.
	PhD supervision Kelly Mills: Effects of oestrogens and wastewater treatment plant effluent on the Western Pygmy Perch. The University of Western Australia.
	Honours Supervision Ruyu Wang: Genetic Diversity of Western Minnow (*Galaxias occidentalis*) along the Swan and Canning river systems. The University of Western Australia.
Rod Lenanton	Adjunct Associate Professor, Faculty of Sustainability, Environmental and Life Sciences, School of Biological Sciences and Technology, Murdoch University.

Staff Member	Position
Justin McDonald	Adjunct Senior Lecturer, Faculty of Natural and Agricultural Sciences - Oceans Institute, University of Western Australia
	PhD co- supervision, University of Western Australia, supervises Tiffany Simpson - ' Factors influencing the establishment of invasive marine species'.
	Technical Advisor and committee member IMarEST Biofouling Expert Management Group
	California State Lands Commission - Biofouling Technical Advisory Group member
	Ministry for Primary Industries New Zealand - Biofouling Technical Advisory Group member
	Member of Technical Advisory Panel (TAP) for the Swan River Trust
	Member CSIRO Biosecurity Flagship Advisory Committee
	Associate Editor Management of Biological Invasions – International Journal
Brett Molony	Member of Marine and Freshwater Course Consultative Committee, Edith Cowan University.
	Member of the Technical Advisory Panel (TAP) for the Swan River Trust
	Adjunct Associate Professor, School of Biological Sciences and Technology , Murdoch University 1/11/2012 – 1/11/2015
Stephen Newman	Adjunct Associate Professor – Marine Ecology Group, School of Plant Biology, University of Western Australia
	Adjunct Professor – Department of Environment and Agriculture, Faculty of Science and Engineering, Curtin University
Kim Smith	Masters co-supervision, Edith Cowan University, supervises Peter Malanczak – 'Influence of hydrological factors on distribution of spawning and recruitment by Perth herring in the upper Swan Estuary'
Michael Snow	Masters Co-supervision, Edith Cowan University, supervises Lia Smith. eDNA: analysis for fresh water fish biodiversity in Western Australia,.
	Honours Co-supervision, University of Western Australia, supervises Katrina West Microsatellite Analysis of Population Genetic Structure in *C. cainii* and *C. tenuimanus* from the south-west of Western Australia.
Michael Travers	Adjunct Research Scientist, Australian Institute of Marine Science
	Honours Co-supervision, University of Western Australia, supervises Elisabeth Myers. Day-night differences in temperate reef fish assemblages.
Corey Wakefield	Adjunct Senior Lecturer, Marine Ecology Group, School of Plant Biology, University of Western Australia
	Honorary Research Fellow, Victoria University of Wellington, New Zealand
	Adjunct Senior Lecturer, Curtin University of Technology
	Masters co-supervision, Curtin University of Technology, supervises Claire Wellington – 'Description and comparison of demersal fish ecology of the continental slope of Western Australia'.
	Masters co-supervision, Curtin University of Technology, supervises Dion Boddington – 'Comparison of the life history characteristics, habitat partitioning and stock status of three groupers off the north-western coast of Australia'.
	Masters co-supervision, Victorian University of Wellington New Zealand, supervises Natalie Stewart – 'The population structure of Polyprionidae from Australia and New Zealand'.
Brent Wise	Adjunct Associate Professor, School of engineering, Faculty of Health, Engineering and Science, Edith Cowan University

GLOSSARY OF ACRONYMS

AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AIMWTMF	Abrolhos Islands and Mid West Trawl Managed Fishery
ASL	Australian Sea Lion
BPMF	Broome Prawn Managed Fishery
BRD	Bycatch Reduction Device
BRUVS	Baited Remote Underwater Video System
CAES	Catch and Effort Statistics
CDR	Catch and disposal record
CI/CKI	Christmas Island and Cocos (Keeling) Island
CILF	Christmas Island Line Fishery
CKIMAFF	Cocos (Keeling) Islands Marine Aquarium Fish Fishery
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSLPF	Cockburn Sound (Line and Pot) Managed Fishery
CW	Carapace Width
DFAC	Developing Fisheries Assessment Committee
DOTE	Department of the Environment (Commonwealth Government) (formerly Department of Sustainability, Environment, Water, Population and Communities)
DPAW	Department of Parks and Wildlife (formerly Department of Environment and Conservation)
EBFM	Ecosystem Based Fisheries Management
ECU	Edith Cowan University
EPBC	(Commonwealth Government) Environment Protection and Biodiversity Conservation (Act 1999)
ERLF	Esperance Rock Lobster Managed Fishery
ESD	Ecologically Sustainable Development
ETP	Endangered, Threatened and Protected
FED	Fish escapement device
FHPA	Fish Habitat Protection Area
FMO	Fisheries and Marine Officer
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act
FRR	Fisheries Research Report
GAB	Great Australian Bight
GDSF	Gascoyne Demersal Scalefish Managed Fishery
HMAS	Her Majesty's Australian Ship
IBSS	Independent Breeding Stock Survey
IFM	Integrated Fisheries Management
IMCRA	Interim Marine and Coastal Regionalisation for Australia
IMP	Introduced Marine Pests
IMS	Introduced Marine Species
ISO	International Organisation for Standardisation
ITQ	Individually Transferable Quota
IUCN	International Union for the Conservation of Nature
IVR	Integrated Voice Response
JANSF	Joint Authority Northern Shark Fishery

JASDGDLF	Joint Authority Southern Demersal Gillnet and Demersal Longline Managed Fishery
KGBF	Kimberley Gillnet and Barramundi Managed Fishery
KPMF	Kimberley Prawn Managed Fishery
LASCF	Lake Argyle Silver Cobbler Fishery
MAF	Marine Aquarium Fish Managed Fishery
MBP	Marine Bioregional Plan
MFL	Managed Fishery Licence
MLL	Minimum Legal Length
MOP	Mother-of-Pearl
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSC	Marine Stewardship Council
MSY	Maximum Sustainable Yield
NBPMF	Nickol Bay Prawn Managed Fishery
NDSF	Northern Demersal Scalefish Managed Fishery
NPF	Northern Prawn Fishery
NRM	Natural Resource Management
NTAC	Notional Target Total Allowable Catch
OCL	Orbital Carapace Length
OPMF	Onslow Prawn Managed Fishery
PFRC	Pemberton Freshwater Research Centre
RAP	Research Angler Program
RCL	Rostrum Carapace Length
RFBL	Recreational Fishing from Boat Licence
RFFSS	Recreational Freshwater Fisheries Stakeholder Subcommittee
RRAMF	Ranked Risk Assessment of Multiple Fisheries
SBBSMNF	Shark Bay Beach Seine and Mesh Net Managed Fishery
SBCIMF	Shark Bay Crab Interim Managed Fishery
SBSF	Shark Bay Snapper Managed Fishery
SCRIP	Strategic Criteria for Rural Investments in Productivity
SCTF	South Coast Trawl Fishery
SFD	Standard Fishing Day
SIEV	Suspected Illegal Entry Vessel
SLED	Sea Lion Exclusion Device
SMFG	Size Management Fish Ground
SSF	Specimen Shell Managed Fishery
SWCC	South West Catchment Council
SWTMF	South West Trawl Managed Fishery
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch
TAE	Total Allowable Effort
TARC	Total Allowable Recreational Catch
TDGDLF	Western Australian Temperate Demersal Gillnet and Demersal Longline Fisheries
UWA	University of Western Australia
TPSA	Tiger Prawn Spawning Area
VFAS	Voluntary Fisheries Adjustment Schemes
VMS	Vessel Monitoring System
WAFIC	Western Australian Fishing Industry Council
WAFMRL	Western Australian Fisheries and Marine Research Laboratories
WAMSI	Western Australian Marine Science Institute
WANCSF	Western Australian North Coast Shark Fishery

WCB	West Coast Bioregion
WCDGDLF	West Coast Demersal Gillnet and Demersal Longline (Interim) Managed Fishery
WCDSF	West Coast Demersal Scalefish Fishery
WCDSIMF	West Coast Demersal Scalefish (Interim) Managed Fishery
WCEF	West Coast Estuarine Managed Fishery
WCRLF	West Coast Rock Lobster Managed Fishery
WDWTF	Western Deepwater Trawl Fishery
WTO	Wildlife Trade Operation