APPENDICES

APPENDIX 1
Fisheries Research Division staff publications 2014/15

Scientific Papers

Abdul Wahab, M.A., de Nys, R., Abdo, D., Webster, N., and Whalan, S. 2014. The influence of habitat on post-settlement processes, larval production and recruitment in a common coral reef sponge, *Journal of Experimental Marine Biology and Ecology* Vol. 461: 162-172

Bentley, B.C., Harvey, E.S., Newman, S.J., Welch, D.J., Smith, A.K. and Kennington, W.J. 2014. Local genetic patchiness but no regional differences between Indo-West Pacific populations of the dogtooth tuna *Gymnosarda unicolor*. *Marine Ecology Progress Series* 506: 267-277.

Braccini, J.M., Brooks, E., Wise, B. & McAuley, R. 2015. Displaying uncertainty in the biological reference points of sharks. *Ocean and Coastal Management* 116: 143–149.

Bridgwood, S.D., Muñoz, J. and McDonald, J.I. 2014. Catch me if you can! The story of a colonial asdician's takeover bid in Western Australia. *BioInvasions Records* 3(4): 217-223.

Caputi, N., de Lestang, S., Reid, C., Hesp, A., & How, J. 2015. Maximum economic yield of the western rock lobster fishery of Western Australia after moving from effort to quota control. *Marine Policy* 51: 452-464.

Chen, Z., Snow, M., Lawrence, C.S., Church, A.R., Narum, S.R., Devlin, R.H. & Farrell, A.P. 2015. Selection for upper thermal tolerance in rainbow trout (*Oncorhynchus mykiss* Walbaum). *Journal of Experimental Biology* 218(Pt 5): 803-12

Close, P.G., Dobbs, R.J., Ryan, T.J., Ryan, K., Speldewinde, P.C., Toussaint, S. 2014. Prediction of potentially significant fish harvest using metrics of accessibility in northern Western Australia. *Journal of the Royal Society of Western Australia* 97: 355–361.

Dang, G.C., Dungan, C.F., Scott, G.P., Reece, K.S. 2015. Perkinsus sp. infections and in vitro isolates from Anadara trapezia (mud arks) of Queensland, Australia. *Diseases of Aquatic Organisms* 113: 51-58.

Dias, P.J., Muñoz, J., Huisman, J.M., and McDonald, J.I. 2015. Biosecurity monitoring of Harmful Algal Bloom (HAB) species in Western Australian waters: first confirmed record of Alexandrium catenella (Dinophyceae). *BioInvasions Records. Volume 4*. Available online at: http://www.reabic.net/journals/bir/2015/Accepted/BIR_2015_Dias_etal_correctedproof.pdf

DiBattista, J.D., Randall, J.E., Newman, S.J. and Bowen, B.W. 2014. Round herring (genus *Etrumeus*) contain distinct evolutionary lineages coincident with a biogeographic barrier along Australia's southern temperate coastline. *Marine Biology* 161 (11): 2465-2477.

Dudgeon, C.L., Pollock, K.H., Braccini, J.M., Semmens J.M. & Barnett, A. 2015. Integrating acoustic telemetry into mark-recapture models to improve the precision of apparent survival and abundance estimates. *Oecologia*, doi: 10.1007/s00442-015-3280-z.

Duffy, R., Ledger, J., Dias, P.J. & Snow, M. 2014. The critically endangered hairy marron, *Cherax tenuimanus* Smith, 1912: A review of current knowledge and actions required to prevent extinction of a species. *Journal of the Royal Society of Western Australia* 97:297-306.

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

Fletcher, W.J. 2015. Review and refinement of an existing qualitative risk assessment method for application within an ecosystem-based management framework. *ICES Journal of Marine Science* 72: 1043-1056. doi:10.1093/icesjms/fsu/142

Fletcher, W.J., Kearney, R.E., Wise, B.S., Nash, W.J. 2015. Large-scale expansion of no-take closures within the Great Barrier Reef has not enhanced fishery production. *Ecological Applications* 25:1187-1196.

Fromont, J. and Abdo, D.A. 2014. New species of Haliclona (Demospongiae: Haplosclerida: Chalinidae) from Western Australia, *Zootaxa*. Vol. 3835 (1): 97–109

Guildea, C., Hitchen, Y., Duffy, R., Dias, P.J., Ledger, J.M., Snow, M., and Kennington, W.J. 2015. Introgression threatens the survival of the critically endangered freshwater crayfish *Cherax tenuimanus* (Decapoda : Parastacidae) in the wild. *Plos-One* DOI: 10.1371/journal.pone.0121075

Hernández, S., Daley, R., Walker, T., Braccini, J.M., Varela, A., Francis, M., Ritchie, P.A. 2015. Demographic history and the South Pacific dispersal barrier for school shark (*Galeorhinus galeus*) inferred by mitochondrial DNA and microsatellite DNA mark. *Fisheries Research* 167: 132–142.

Hobbs, J-P.A., Coker, D.J., Green, P.T., James, D.J., Humphreys, W.F., McAllan, I.A.W., Newman, S.J., Pratchett, M.S., Staeudle, T.M., Whiting, S.D. 2014. An annotated bibliography of the research on marine organisms and environments at Christmas Island and the Cocos (Keeling) Islands. *Raffles Bulletin of Zoology Supplement* 30: 419-468.

Hobbs, J-P.A., Newman, S.J., Mitsopoulos, G.E.A., Travers, M.J., Skepper, C.L., Gilligan, J.J., Allen, G.R., Choat, J.H. and Ayling, A.M. 2014. Fishes of the Cocos (Keeling) Islands: new records, community composition and biogeographic significance. *Raffles Bulletin of Zoology Supplement* 30: 203-219.

Hobbs, J-P.A., Newman, S.J., Mitsopoulos, G.E.A., Travers, M.J., Skepper, C.L., Gilligan, J.J., Allen, G.R., Choat, J.H. and Ayling, A.M. 2014. Checklist and new records of Christmas Island fishes: the influence of isolation, biogeography and habitat availability on species abundance and community composition. *Raffles Bulletin of Zoology Supplement* 30: 184-202.

Hourston, M., McDonald, J.I., Hewitt, M.J. 2015. Public engagement for the detection of the introduced marine species Charybdis japonica in Western Australia. *Management of Biological Invasions* Volume 6 (3): 243-252.

Kennington, J., Guildea, C., Lukehurst, S., Hitchen, Y., Gardner, M., Duffy, R., Dias, J., Ledger, J. & Snow, M. 2014 Isolation and characterization of 13 polymorphic microsatellite loci for the smooth *Cherax cainii* and hairy marron *C. tenuimanus* (Decapoda: Parastacidae)' *Conservation Genetics Resources* Vol 6, No. 2: 337-339.

McDonald, J.I., Huisman, J.M., Hart, F.N., Dixon, R.R.M., and Lewis, J.A. 2015. The first detection of the invasive macroalga *Codium fragile* subsp. fragile (Suringar) Hariot in Western Australia. *BioInvasions Records* 3(4): 75-80

Metcalf, S.J., Van Putten, E.I., Frusher, S., Marshall, N. A., Tull, M., Caputi, N., Haward, M., Hobday, A.J., Holbrook, N.J., Jennings, S.M., Pecl, G.T. and Shaw, J. 2015. Measuring the vulnerability of marine social-ecological systems: a prerequisite for the identification of climate change adaptations. *Ecology and Society* 20 (2): 35. [online] URL: http://www.ecologyandsociety.org/vol20/iss2/art35/

Muñoz, J., Page, M., McDonald, J.I., and Bridgwood, S.D. 2015. Aspects of the growth and reproductive ecology of the introduced ascidian *Didemnum perlucidum* (Monniot, 1983) in Western Australia. *Aquatic Invasions* (2015) Volume 10: 265-274.

Nolan, D., Stephens, F., Crockford, M., Jones, J.B. & Snow, M. 2015. Detection and characterisation of viruses of the genus Megalocytivirus in ornamental fish imported into an Australian border quarantine premises: an emerging risk to national biosecurity. *Journal of Fish Diseases* 38 (2) 187-195

Oliver, S., Braccini, M., Newman, S.J. & Harvey, E.S. 2015. Global patterns in the bycatch of sharks and rays. *Marine Policy* 54: 89–97.

Penn, J.W., Caputi, N., de Lestang, S. 2015. A review of lobster fishery management: the Western Australian fishery for *Panulirus cygnus*, a case study in the development and implementation of input and output-based management systems. *ICES Journal of Marine Science* doi:10.1093/icesjms/fsv057

Perez, M., Braccini, J.M., & Cousseau, M.B. 2014. Uso de marcas convencionales en un país con escasa experiencia en marcación de peces marinos. *Latin American Journal of Aquatic Research* 42: 258–263 (in Spanish).

Santana-Garcon, J., Braccini, M., Langlois, T.J., Newman, S.J., McAuley, R.B. & Harvey, E.S. 2014. Calibration of pelagic stereo-BRUVs and scientific longline surveys for sampling sharks. *Methods in Ecology and Evolution* 5 (8): 824-833. doi: 10.1111/2041-210X.12216.

Santana-Garcon, J., Leis, J.M., Newman, S.J. and Harvey, E.S. 2014. Presettlement schooling behaviour of a priacanthid, the Purplespotted Bigeye Priacanthus tayenus (Priacanthidae: Teleostei). *Environmental Biology of Fishes* 97 (3): 277-283.

Santana-Garcon, J., Newman, S.J. and Harvey, E.S. 2014. Development and validation of a mid-water baited stereo-video technique for investigating pelagic fish assemblages. *Journal of Experimental Marine Biology and Ecology* 452: 82-90.

Santana-Garcon, J., Newman, S.J., Langlois, T.J. and Harvey, E.S. 2014. Effects of a spatial closure on highly mobile fish species: an assessment using pelagic stereo-BRUVs. *Journal of Experimental Marine Biology and Ecology* 460: 153-161.

Shedrawi, G., Harvey, E.S., McLean, D.L., Prince, J., Bellchambers, L.M. and Newman, S.J. 2014. Evaluation of the effect of closed areas on a unique and shallow water coral reef fish assemblage reveals complex responses. *Coral Reefs* 33 (3): 579-591.

Taylor, S.M., Johnson, J.W., Bennett, M.B. 2015. Spatial gradient in the distribution of whaler sharks (Carcharhinidae) in Moreton Bay, southeastern Queensland. Memoirs of the Queensland Museum, *Nature* 59: 39-53 http://dx.doi.org/10.17082/j.2204-1478.59.2015.2014-08

Trinnie, F.I., Walker, T.I., Jones, P.L., Laurenson, L.J. 2014. Regional differences in the reproductive parameters of the sparsely-spotted stingaree, *Urolophus paucimaculatus*, from south-eastern Australia. *Marine and Freshwater Research* 65: 943–958.

Book Contributions

Cochrane, K., Bianchi, G., Fletcher, W., Fluharty, D., Mahon, R., O. Arve Misund 2014. Regulatory and Governance Frameworks. In: *The Sea Volume 16. Marine Ecosystem-Based Management. Chapter 4*. Pp 77-119 eds. Fogarty et al. Harvard Univ. Press, London.

Reports

Bellchambers, L.M. and Pember, M. B. 2014. Assessing the ecological impact of the western rock lobster fishery in fished and unfished areas FRDC Project 2008/013. *Fisheries Research Report No. 254.* Department of Fisheries, Western Australia. 108pp.

Bridgwood, S. 2015 Garden Island Marine Pest Incursion Response Plan. Developed for the Commonwealth of Australia represented by Department of Defence (Defence Support Central and West – WA). *Department of Fisheries Report* 86pp.

Bridgwood, S.D., McDonald, J.I. 2014. A likelihood analysis of the Introduction of Marine Pests to Western Australian Ports via Commercial Vessels. *Fisheries Research Report No. 259*. Department of Fisheries, Western Australia. 212 pp.

Campbell, M., Clark, G., Dafforn, K., Deveney, M., Garside, C., Hewitt, C., McDonald, J., Piola, R. 2014. White Paper on Nonindigenous Marine Species effects to Biodiversity Conservation and Ecosystem Health. Report to the National Marine Science Committee for the *National Marine Science Plan. Department of Fisheries Report.*

Caputi, N., Feng, M., Pearce, A., Benthuysen, J., Denham, A., Hetzel, Y., Matear, R., Jackson, G., Molony, B., Joll, L., and Chandrapavan, A. 2015. Management implications of climate change effect on fisheries in Western Australia: Part 1 Environmental change and risk assessment. FRDC Project 2010/535. *Fisheries Research Report 260*, Department of Fisheries, Western Australia, 180pp. DOI: 10.13140/RG.2.1.2240.7200

Caputi, N., Feng, M., Pearce, A., Benthuysen, J., Denham, A., Hetzel, Y., Matear, R., Jackson, G., Molony, B., Joll, L., and Chandrapavan, A. 2015. Management implications of climate change effect on fisheries in Western Australia: Part 2: Case studies. FRDC Project 2010/535. *Fisheries Research Report 261*, Department of Fisheries, Western Australia, 156pp.

Caputi, N., de Lestang, S., Reid, C., Hesp, A., How, J. 2014. Decision-support tools for economic optimization of western rock lobster fishery of Western Australia. *Fisheries Research Report 257*, Department of Fisheries, Western Australia, 100pp.

Department of Fisheries. 2014. Exmouth Gulf Prawn Managed Fishery harvest strategy 2014-2019. *FisheriesManagement Paper No. 265.* 32pp.

Department of Fisheries. 2014. Exmouth Gulf Prawn Managed Fishery bycatch action plan 2014-2019. *FisheriesManagement Paper No. 266.* 24pp.

Department of Fisheries. 2014. Shark Bay Prawn Managed Fishery harvest strategy 2014-2019. *Fisheries Management Paper No.267.* 32pp.

Department of Fisheries. 2014. Shark Bay Prawn Managed Fishery bycatch action plan 2014-2019. *Fisheries Management Paper No.268.* 24pp.

Johnston, D., Chandrapavan, A., Wise, B. and Caputi, N. 2014. Assessment of blue swimmer crab recruitment and breeding stock levels in the Peel-Harvey Estuary and status of the Mandurah to Bunbury Developing Crab Fishery. *Fisheries Research Report No. 258.* Department of Fisheries, Western Australia. 148pp.

Lewis, P. 2015. Further investigation into critical habitat for juvenile dhufish (*Glaucosoma hebraicum*), artificial habitats and the potential to monitor annual juvenile recruitment. NRM Project 09038 – Protecting inshore and demersal finfish. *Fisheries Research Report No. 265*. Department of Fisheries, Western Australia. 80pp.

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

Muñoz, J. 2014 Early Warning System for the Monitoring of Introduced Marine Pests. HMAS Stirling Final Report 2013. Report Prepared for the Department of Defense, Government of Australia. *Department of Fisheries Report* 20 pp.

Muñoz, J. 2015 Early Warning System for the Monitoring of Introduced Marine Pests. Southern Ports Authority (Port of Esperance) and Bandy Creek Boat Harbour Annual Report 2013-14. Report Prepared for Southern Ports Authority and Department of Transport. *Department of Fisheries Report* 28 pp.

Piola, R., McDonald, J.I., Lewis, J., Coutts, A., Clark, G. 2014. White Paper on Biosecurity and Marine Pests in Coastal Waters. Report to the National Marine Science Committee for the *National Marine Science Plan. Department of Fisheries Report.*

Popular Article

Caputi, N, Wahle, R., Oppenheim, N. 2015 (Ed.) The Lobster Newsletter. 28(1). *Department of Fisheries*, Western Australia. January 2015. http://www.fish.wa.gov.au/Documents/rock_lobster/the_lobster_newsletter/lobster_newsletter_v28_no1.pdf

APPENDIX 2
Table of catches from fishers' statutory monthly returns for 2013/14

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.

	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH				
Carcharhinidae				
	Bronze Whaler	*Carcharhinus brachyurus*	29	45
	Dusky Whaler	*Carcharhinus obscurus*	88	140
	Sandbar Shark	*Carcharhinus plumbeus*	29	46
	Spinner Shark	*Carcharhinus brevipinna*	22	35
	Tiger Shark	*Galeocerdo cuvier*	3	5
Lamnidae				
	Shortfin Mako	*Isurus oxyrinchus*	2	3
Orectolobidae				
	Wobbegong Sharks	Orectolobidae	18	28
Pristiophoridae				
	Common Sawshark	*Pristiophorus cirratus*	4	8
Rajidae				
	Skates	Rajidae	5	13
Sphyrnidae				
	Hammerhead Sharks	Sphyrnidae	36	57
Triakidae				
	Gummy Shark	*Mustelus antarcticus*	286	455
	Pencil Shark	*Hypogaleus hyugaensis*	1	2
	Whiskery Shark	*Furgaleus macki*	106	159
	Shovelnose/Fiddler Rays	Rhinobatidae & Rhynchobatidae	0	1
	Shark, Other		9	19
Ariidae				
	Catfishes	Ariidae	11	11
Berycidae				
	Bight Redfish	*Centroberyx gerrardi*	31	32
	Redfish	*Centroberyx spp.*	7	7
	Yelloweye Redfish	*Centroberyx australis*	2	2

	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Clupeidae				
	Australian Sardine (Pilchard)	*Sardinops sagax*	1516	1516
	Maray	*Etrumeus teres*	2	2
	Perth Herring	*Nematalosa vlaminghi*	1	1
	Sandy Sprat (Whitebait)	*Hyperlophus vittatus*	12	12
Hemiramphidae				
	Southern Garfish	*Hyporhamphus melanochir*	18	18
Platycephalidae				
	Flatheads	Platycephalidae	8	8
Plotosidae				
	Estuary Cobbler	*Cnidoglanis macrocephalus*	51	71
Latidae				
	Barramundi	*Lates calcarifer*	35	57
Polyprionidae				
	Bass Groper	*Polyprion americanus*	1	1
	Hapuku	*Polyprion oxygeneios*	8	8
Epinephelidae				
	Barcheek Coral Trout	*Plectropomus maculatus*	12	12
	Birdwire Rockcod	*Epinephelus merra*	2	2
	Blackspotted Rockcod	*Epinephelus malabaricus*	25	25
	Breaksea Cod	*Epinephelides armatus*	5	5
	Chinaman Rockcod	*Epinephelus rivulatus*	2	2
	Common Coral Trout	*Plectropomus leopardus*	2	2
	Duskytail Grouper	*Epinephelus bleekeri*	4	4
	Eightbar Grouper	*Hyporthodus octofasciatus*	13	13
	Flowery Rockcod	*Epinephelus fuscoguttatus*	43	43
	Goldspotted Rockcod	*Epinephelus coioides*	33	33
	Rankin Cod	*Epinephelus multinotatus*	108	108
	Tomato Rockcod	*Cephalopholis sonnerati*	1	1
	Cods	*Epinephelus/Cephalopholis*	57	57
Glaucosomatidae				
	Northern Pearl Perch	*Glaucosoma buergeri*	20	20
	West Australian Dhufish	*Glaucosoma hebraicum*	66	67
Priacanthidae				
	Bigeyes	Priacanthidae	20	20
Terapontidae				
	Trumpeters	Terapontidae	3	3
	Yellowtail Grunter	*Amniataba caudavittata*	1	1
Sillaginidae				
	King George Whiting	*Sillaginodes punctatus*	14	14
	Whitings	Sillaginidae	92	92
	Yellowfin Whiting	*Sillago schomburgkii*	65	65
Pomatomidae				
	Tailor	*Pomatomus saltatrix*	24	24

	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
Rachycentridae				
	Cobia	*Rachycentron canadum*	13	13
Carangidae				
	Amberjack	*Seriola dumerili*	14	14
	Black Pomfret	*Parastromateus niger*	2	2
	Golden Trevally	*Gnathanodon speciosus*	3	3
	Queenfish	*Scomberoides commersonnianus*	0	2
	Samson Fish	*Seriola hippos*	35	37
	Silver Trevally	*Pseudocaranx* spp.	5	5
	Trevallies	Carangidae	130	130
	Yellowtail Kingfish	*Seriola lalandi*	2	2
	Yellowtail Scad	*Trachurus novaezelandiae*	16	16
Arripidae	Australian Herring	*Arripis georgianus*	154	154
	Western Australian Salmon	*Arripis truttaceus*	327	328
Lutjanidae				
	Brownstripe Snapper	*Lutjanus vitta*	64	64
	Chinaman Fish	*Symphorus nematophorus*	9	9
	Crimson Snapper	*Lutjanus erythropterus*	259	259
	Darktail Snapper	*Lutjanus lemniscatus*	14	14
	Flagfish/Spanish Flag	*Lutjanus vitta/quinquelineatus/carponotatus/lutjan*	26	26
	Goldband Snapper	*Pristipomoides multidens*	648	648
	Mangrove Jack	*Lutjanus argentimaculatus*	11	11
	Moses Snapper	*Lutjanus russelli*	34	34
	Red Emperor	*Lutjanus sebae*	232	232
	Rosy Snapper	*Pristipomoides filamentosus*	7	7
	Ruby Snapper	*Etelis carbunculus*	16	16
	Saddletail Snapper	*Lutjanus malabaricus*	167	167
	Sharptooth Snapper	*Pristipomoides typus*	1	1
	Stripey Snapper	*Lutjanus carponotatus*	1	1
	Tropical Snappers	Lutjanidae	8	8
Nemipteridae				
	Monocle Bream	*Scolopsis spp.*	5	5
	Threadfin Breams	Nemipteridae	75	75
Lobotidae				
	Tripletail	*Lobotes surinamensis*	1	1
Haemulidae				
	Javelin Fish	*Pomadasys spp.*	44	44
	Painted Sweetlips	*Diagramma labiosum*	12	12
	Sweetlips	Haemulidae	43	43
Lethrinidae				
	Bluespotted Emperor	*Lethrinus punctulatus*	201	201
	Drab Emperor	*Lethrinus ravus*	4	4
	Emperors	Lethrinidae	1	1

	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
	Grass Emperor	*Lethrinus laticaudis*	5	5
	Longnose Emperor	*Lethrinus olivaceus*	15	15
	Mozambique Seabream	*Wattsia mossambica*	8	8
	Redspot Emperor	*Lethrinus lentjan*	20	20
	Redthroat Emperor	*Lethrinus miniatus*	55	55
	Robinson's Seabream	*Gymnocranius grandoculis*	21	21
	Spangled Emperor	*Lethrinus nebulosus*	60	60
Sparidae				
	Black Bream	*Acanthopagrus butcheri*	38	38
	Frypan Bream	*Argyrops spinifer*	31	31
	Snapper (Pink Snapper)	*Chrysophrys auratus*	484	487
	Tarwhine	*Rhabdosargus sarba*	4	4
	Western Yellowfin Bream	*Acanthopagrus morrisoni*	18	18
Sciaenidae				
	Black Jewfish	*Protonibea diacanthus*	2	3
	Mulloway	*Argyrosomus japonicus*	17	18
Mullidae				
	Red Mullet	Mullidae	15	15
Clupeidae				
	Scaly Mackerel	*Sardinella lemuru*	974	974
Kyphosidae				
	Sea Sweep	*Scorpis aequipinnis*	1	1
Pentacerotidae				
	Boarfish	Pentacerotidae	6	6
Oplegnathidae				
	Knifejaw	*Oplegnathus woodwardi*	1	1
Cheilodactylidae				
	Blue Morwong	*Nemadactylus valenciennesi*	37	41
Mugilidae				
	Mullets	Mugilidae	2	2
	Sea Mullet	*Mugil cephalus*	198	198
	Yellow-Eye Mullet	*Aldrichetta forsteri*	22	22
Sphyraenidae				
	Pikes	Sphyraenidae	3	3
	Snook	*Sphyraena novaehollandiae*	2	2
Polynemidae				
	King Threadfin	*Polydactulus macrochir*	31	42
	Threadfin	Polynemidae	2	2
Labridae				
	Baldchin Groper	*Choerodon rubescens*	12	12
	Blue Groper	*Achoerodus gouldii*	33	40
	Bluespotted Tuskfish	*Choerodon cauteroma*	3	3
	Parrotfishes	Scarinae	2	2
	Pigfish	*Bodianus* spp.	1	1

	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
FISH (Continued)				
	Tuskfishes	*Choerodon spp.*	2	2
	Wrasses	Labrinae	1	1
Scombridae				
	Bonito	*Sarda australis*	14	14
	Grey Mackerel	*Scomberomorus semifasciatus*	5	5
	Mackerel, Other	Scombridae	0	0
	Spanish Mackerel (Narrow-barred)	*Scomberomorus commerson*	213	294
	Tuna, Other	Scombridae	1	1
Centrolophidae				
	Blue-Eye Trevalla	*Hyperoglyphe antarctica*	1	1
Bothidae				
	Flounder	Bothidae	2	3
Monacanthidae				
	Leather Jacket	Monacanthidae	12	22
	Fish, other		131	153
	TOTAL FISH		8043	8612
CRABS				
	Crystal Crab	*Chaceon albus*	152	152
	Champagne Crab	*Hypothalassia acerba*	1	1
	Giant Crab	*Pseudocarcinus gigas*	10	10
	Blue swimmer Crab	*Portunus armatus*	549	549
	Mud Crab	*Scylla spp.*	10	10
	TOTAL CRABS		723	723
PRAWNS				
	Banana Prawn	*Penaeus merguiensis*	425	425
	Brown Tiger Prawn	*Penaeus esculentus*	724	724
	Coral Prawn	*Metapenaeopsis spp.*	141	141
	Endeavour Prawn	*Metapenaeus endeavouri*	110	110
	Western King Prawn	*Penaeus latisulcatus*	1538	1538
	Prawns, Other	Penaeidae	1	1
	TOTAL PRAWNS		2939	2939
LOBSTERS				
	Southern Rock Lobster	*Jasus edwardsii*	46	46
	Western Rock Lobster	*Panulirus cygnus*	5811	5811
	Bugs/ Slipper lobster	Scyllaridae	7	7
	TOTAL LOBSTERS		5863	5863
MOLLUSCS				
	Squid	*Sepioteuthis spp./Loligo spp.*	40	40
	Octopus	*Octopus (cf.) tetricus*	161	209

	Common Name	Scientific Name	Landed Weight (tonnes)	Live Weight (tonnes)
MOLLUSCS (Continued)				
	Cuttlefish	Sepiidae	35	35
	Saucer scallop	*Amusium balloti*	56	280
	Brownlip Abalone	*Haliotis conicopora*	11	28
	Greenlip Abalone	*Haliotis laevigata*	54	145
	Roe's Abalone	*Haliotis roei*	66	66
	Molluscs, Other		0	0
	TOTAL MOLLUSCS		424	803
	OTHER INVERTEBRATES		19	56
GRAND TOTAL			**18010**	**18995**

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 2013/14

Highlights for 2013/14

There were 453 licensed aquaculture producers

The farm gate value of aquaculture production in WA (excluding marine algae and pearl oysters) was just under $14.68 million

The most valuable industry sector was barramundi ($7.8 million), followed by marron ($1.41 million), mussels ($0.79 million) and yabbies ($0.30 million)

The industry sector with the most participants was marron with 184 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 2013/14. 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 2015.

Note that all production reported in tonnes throughout this document refers to whole weight and the farm gate value refers to the value of product at the first point of recorded sale.

The Industry in 2013/14

A total of 453 aquaculture licence holders were required to submit quarterly returns for one or more quarters in the 2013/14 financial year. Of the 453 licences, 218 i.e. 48 per cent recorded production on their returns. Marron had the largest number of producers with 184 licences recording production (Table 1).

Estimated aquaculture production decreased from 1663 tonnes produced in 2012/13 to 1015 tonnes in 2013/14 (excludes algae, pearl oysters, and ornamental species) (Table 2).

The estimated value of Western Australian aquaculture (excluding algae and pearl oysters) decreased from $16.85 million to $14.68 million in 2013/14 (Table 3). Finfish aquaculture made up 55 per cent of the total value for 2013/14.

AQUACULTURE PRODUCTION TABLE 1.

Growout production for the Western Australian aquaculture industry in 2013/14

Common name	Productive licences	Quantity	Units*	Average price ($)/ kg or individual	Value ($)
Barramundi	5	699	tonnes	11.18	7,814,198
Marron	184	47	tonnes	29.62	140,551
Mussels	5	188	tonnes	4.19	785,364
Yabbies	7	15	tonnes	20.36	303,572
Silver perch	10	14	tonnes	19.61	280,338
Koi carp	6	52,015	No.	3.40	177,083
Ornamental fish	5	15,388	No.	n/a	67,511
Goldfish		25,902	No.	1.83	47,287
Rainbow trout	7	3	tonnes	11.66	31,642
Ornamental crustaceans	5	4,736	No.	n/a	26,759
Other species with <5 producers**	<5			n/a	3,736,299
Algae	<5	**			**
Total (not including algae or pearls)					14,675,554

* 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 2007/08-2013/14

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	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Barramundi	tonnes	365.9	455.2	433	862.5	1 127.0	1 190.0	699
Mussels	tonnes	481.2	433.5	506.5	364.9	349.8	242.6	188
Marron	tonnes	51.1	52.8	53.9	51.1	51.3	51.9	47
Yabbies	tonnes	60.8	44.1	46.7	19.7	18.8	19.4	15
Silver perch	tonnes	16.9	28.5	27.2	18	14.1	12.9	14
Rainbow trout	tonnes	13.3	11.7	7.5	11	4.2	4.3	3
Ornamental fish & crustaceans	No.	55 047	50 598	46 425	21 167	26 538	22 796	20124
Koi carp	No.	35 620	34 270	44 787	39 944	41 366	50 210	52015
Goldfish	No.	33 918	36 199	15 785	11 448	8 624	12 975	25902
Other species with < 5 producers	tonnes	97.2	94.9	94.2	75	97.4	43.6	48.3

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	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Barramundi	3 870 071	4 793 106	4 512 123	8 391 579	11 143 391	12 510 851	7 814 198
Marron	1 298 672	1 434 494	1 445 252	1 418 951	1 471 608	1 508 755	1 405 501
Mussels	1 531 849	1 618 594	1 870 531	1 357 009	1 367 470	1 017 041	785 364
Yabbies	1 059 532	810 608	760 595	389 920	376 830	415 581	303 572
Silver perch	245 157	405 506	435 624	310 977	254 883	254 561	280 338
Koi carp	160 597	168 279	184 708	173 928	148 751	185 094	177 083
Rainbow trout	135 007	140 422	101 681	133 257	61 012	63 956	31 642
Ornamental fish & crustaceans	237 408	276 986	230 856	108 023	68 468	76 972	94 270
Goldfish	80 732	73 992	52 139	32 771	25 759	36 793	47 287
Other	1 554 289	1 715 130	1 018 211	1 024 396	1 337 601	775 734	3 736 299
Total (not including algae & pearls)	10 173 312	11 437 116	10 611 720	13 304 811	16 255 773	16 845 338	14 675 554

APPENDIX 3
Research Division - Other Activities
Activities of the Pemberton Freshwater Research Centre and the Aquaculture & Native Fish Breeding Laboratory 2014/15

C. Lawrence and T. Church

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.

The Aquaculture and Native Fish Breeding Laboratory is located at the UWA Field Station, Shenton Park. It is the result of a long term collaborative research partnership between UWA and Department of Fisheries. For the past 20 years this partnership has successfully addressed strategic state government aquatic research priorities and trained postgraduate students. The laboratory is the largest recirculating freshwater aquaculture research facility in Australia, consisting of over 2 million litres including; 30 x 20,000 L tanks, 9 x 5,000 L tanks, 10 x 2,000 L tanks, 24 x 150 L tanks, 8 x 500 L tanks, 2 x 1000 L broodstock conditioning tanks, hatchery troughs, 3 x 220,000 L artificial lakes, 12 x 1000 L aquaponics tanks, 100 x 100 L aquariums and a 12 x 310 L quarantine facility. It is the only hatchery producing disease free genotyped native and endangered fish species in the state. At this facility both UWA and Department of Fisheries staff and post-graduate students undertake advanced and technically challenging leading edge research into aquatic biology and aquaculture across a broad field including reproduction, larval rearing, nutrition, strain selection, translocation, experimental design, conservation biology, production systems, husbandry, selective breeding, biological control and species variation.

Key PFRC and Aquaculture and Native Fish Breeding Laboratory projects in 2014/15 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 2014/15 the PFRC produced 666,500 fry. These consisted of 664,000 rainbow trout fry and 2,500 brown trout fry, representing an decrease in production of 4% and a decrease of 82% respectively, compared with 2013/14. The majority of production (71%) consisting of 471,000 rainbow trout fry and 1,500 brown trout yearlings (fry held over summer) was stocked into public waterways to support recreational fishing. A further 158,000 rainbow trout (24%) 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 17% decrease in sales from PFRC in 2014/15 to 158,000 down from 190,000 in 2013/14.

76,000 sterile triploid rainbow trout were produced at PFRC in 2014/15 of which 45,000 were released to a public waterway with the balance supplied to licensed aquaculture producers and fishing associations. The remaining 35,000 diploid trout produced (5%) were retained for future brood stock for PFRC, yearling stocking, and research.

In the winter-spring months of 2014 and May-June 2015 16,250 (27,600 in 2013/14) rainbow yearlings and 2,600 brown yearlings as well as 2,400 rainbow and 345 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

Rainbow trout brood stock selection

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 confirming the unique thermal tolerance of PFRC trout and was published in 2015.

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, UWA Aquaculture and Native Fish Breeding Laboratory. Fish were successfully held at the facility over summer despite air temperatures in excess of 40oC and water temperatures of approximately 28oC. 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. Prior to the 2015 spawning season the stock were then relocated from Shenton Park back to PFRC to enable comparison between the heat challenged and PFRC stocks and to establish a genetic line selected for heat tolerance.

Native and endangered fish conservation and biodiversity research

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 and Native Fish Breeding Laboratory for restocking the Swan Coastal Plain; and a southern genetic line at PFRC.

The aim of this research is to develop large-scale production techniques for native fish species to 1) enable stocking of public and private water bodies, 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).

Broodstock populations of Pygmy perch (*Nannoperca vittata*), Western minnows (*Galaxias occidentalis*), Western trout minnow (*Galaxias truttaceus* - Critically endangered) and Balstons perch (*Nannatherina balstoni* - Vulnerable to extinction) were established at the UWA Aquaculture and Native Fish Breeding Laboratory in Shenton Park. In a world first, intensive hatchery production of Pygmy perch, Western minnow and the critically endangered Western trout minnow were achieved at the Aquaculture and Native Fish Breeding Laboratory in 2014/15. Disease free, genotyped Pygmy perch and Western minnows produced at the Aquaculture and Native Fish Breeding Laboratory were used to restock Lake Marmion Myaree, after the eradication of feral catfish, in 2015.

Broodstock populations of Pygmy perch (*Nannoperca vittata*), Western minnows (*Galaxias occidentalis*) were established at PFRC and spawned in research ponds at the facility.

Mosquito predation

While it has been widely accepted that native fish consume more mosquito larvae than the introduced mosquito fish (*Gambusia holbrooki*) this has not been previously scientifically verified. In a series of experiments Department of Fisheries' researchers quantified the mosquito larvae consumption of key native fish and *Gambusia holbrooki*. These results show that native fish, particularly *Galaxias*, consume more mosquito larvae than *Gambusia holbrooki*.

For mosquito control, endemic fish species offer potential to supplement larviciding efforts as part of an integrated vector control programme. This research, which has been submitted for peer review and publication, will also determine which species is the most suitable for stocking artificial water bodies in which control of mosquito borne viruses, 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 UWA Aquaculture and Native Fish Breeding Laboratory. This research investigated the relationship between size of trout and rates of consumption. Data is being prepared for publication, however early results suggest that presence of trout in water bodies will have a significant impact on reducing feral *Gambusia* 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 UWA 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.

Summary

In early 2015 the Department was required to reduce expenditure. Consequently in May 2015 the Freshwater section vacated the Aquaculture and Native Fish Breeding Laboratory, Shenton Park. The outcome of this was the cessation of research into i) Control of mosquito born viruses by endemic fish species, ii) Large scale hatchery production of native fish for restocking, iii) Captive breeding of endangered fish species for conservation, iv) Selection for high temperature tolerance of rainbow trout, v) Feral fish (*Gambusia*) control methods. It also required the cessation of maintaining a repository of i) The valuable PFRC trout line to reduce the risk of loss of trout with the highest known temperature tolerance of any stock worldwide, ii) Captive populations of endangered native fish species to reduce their risk of extinction, which due to their limited distribution could occur from a single bushfire or waterway pollution event

Core activities for recreational and aquaculture stakeholders, including trout production and monitoring of recreational marron fishery, will continue to be delivered from PFRC.

Activities of the Fish Health Unit during 2014/15

The Fish Health Laboratory 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 research scientist, one full time and one part-time fish pathologist, one senior research scientist, one laboratory manager, and two part-time technical officers.

The laboratory is accredited to ISO 17025 and provides a diagnostic service and advice to the seafood industries in Western Australia, undertakes disease surveillance for key fisheries, investigates 'fish kills', contributes to policy advice developed by the Department, and carries out research on diseases of aquatic organisms. In addition, protocols for high health hatchery status have been developed and adopted by key industries. Key activities and achievements of the unit during 2014/15 were as follows:

The Fish Health Laboratory received a total of 133 diagnostic cases during 2014/15.

The provision of pearling translocation certificates increased from 6 to 9 in this reporting period. Two hatcheries are currently operating in the state: Cygnet Bay Pearls and Clipper Pearls. Paspaley has relocated its pearl oyster hatchery to Darwin.

There were 9 cases of notifiable diseases reported in 2014/15. All notifications related to records of Megalocytivirus in ornamental fish in quarantine facilities at the border following importation from overseas.

In January and February 2015, the Fish Health Laboratory investigated the presence of cysts in the flesh of marron obtained from Grimwade dam (Manjimup shire) and found that the marron were infected by a trematode parasite belonging to the *Choanocotyle* genus. This parasite has since been reported in various locations within the south-west. The laboratory will continue to investigate the life cycle of this worm which likely represents a native species and does not pose a risk to human health

The Fish Health Laboratory has provided support to the invertebrate team of the Research division during the period 2014/15 through the investigation of diseases/ parasites in wild-caught scallop and crab populations sampled at different locations within the state.

The Fish health Laboratory has provided health certification for restocking projects for several species: brown and rainbow trout released in the south west , Roe's abalone released in the mid-west, Western School Prawns released in the Swan and Canning Rivers and barramundi released in the north of the state.

In collaboration with the staff from the Department of Water, 2 reports of 'fish kills' throughout the State were investigated. These '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. Fish kill training was provided by members of the Fish Health Laboratory for personnel who may need to respond to fish kill incidents. In 2014/15, the training occurred within the metropolitan area and in several regional centres. The laboratory is developing a new fish kill training program, including an online training element that will be hosted by the Department of Agriculture and planning Perth-based training in the second half of the year.

A project funded by the FRDC (2013/002) aimed at investigating the cause of diseases in pearl oysters (*Pinctada maxima)* was progressed. The project is in collaboration with Macquarie University and the Pearling industry and exploits 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 2 year FRDC project 2014/002 to develop control material for molecular tests for detection of important endemic and exotic pathogens has progressed. This project is in collaboration with the national reference laboratory for animal diseases: CSIRO Australian Animal Laboratory.

The Fish Health Laboratory is also involved in the FRDC project 2014/001 that aims to develop strategic approaches to identifying pathogens of quarantine concern associated with

the importation of ornamental fish. This project started in 2014/15.

A range of national committees including: the national SCAAH (Subcommittee for Aquatic Animal Health); the AqCCEAD (aquatic Consultative Committee on Emergency Animal Disease); 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 Fish Health Laboratory has also engaged in the national program of proficiency testing through the LEADDR (Laboratories for Emergency Animal Disease Diagnosis and Response) and ANQAP (Australian National Quality Assurance Program) programs. These programs allow laboratories to verify that they provide a reliable diagnostic service and allow the comparison of results between participating Australian laboratories.

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

Indian Ocean Territories Fishery Status Report

S.J. Newman, L. Bellchambers, C. Skepper, S. Evans and P. Dobson

Main Features

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

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 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) and Christmas Islands targeting both finfish and invertebrate species. The Cocos (Keeling) Islands consist of a diverse range of fishable environments that include a sheltered lagoon, fringing reefs and offshore 'blue water'. These environments support a range of demersal and pelagic finfish species, as well as various crustaceans (e.g. lobsters, crabs) and molluscs (e.g. gong gong, clams) that are highly sought after by fishers for both individual and community purposes. Christmas Island, on the other hand, has a limited environments available for fishing with no lagoon present, fringing reef surrounding the island and offshore 'blue water' are the only environments and support primarily pelagic fish species and a limited range of demersal finfish 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 Licences 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 three licences in the fishery, of which two operated during 2014. 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 finfish assemblages at the Indian Ocean Territories. 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). A report is currently in preparation.

Retained Species

Commercial landings (season 2014) Not reported due to confidentiality provisions

Pelagic species dominate the catch of the CILF, comprising 94% of the total reported catch. Wahoo (*Acanthocybium solandri*) is the main target species of the CILF, comprising 80% 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 6% of the total reported catch in 2014. The commercial catch for Christmas Island usually consists of catch data from only two 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 eight 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 licence in the CKIMAFF the catch data is not reportable due to confidentiality provisions.

Recreational catch estimate (season 2014) 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 had been increasing steadily over the previous five years; however in 2014 effort was lower than in previous years. 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 risk assessments undertaken for the marine resources of the Cocos (Keeling) Islands by the Department of Fisheries. 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 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 advised that recreational fishers in the waters of the lagoon targeted these species using lines. This species was extremely low in abundance at the Cocos (Keeling) Islands (Hobbs, Choat pers. comm.), suggesting local depletion and/or overexploitation of the stock. However, recent large recruitment events appear to have led to a stock recovery for this species.

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.

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.

Little is known about the biology of *C. joculator* although Allen *et al*. (2007)[1] 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 three people were employed in the CILF around Christmas Island during 2014. This estimate is based on the number of vessels reporting catches and the average number of crew on each boat.

At least two people were employed in the CKIMAFF around Cocos (Keeling) Islands during 2014.

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 2014:

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 AU$700.00 each).

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 (2015)

A new, multiple year Service Delivery Arrangement with the Commonwealth is being negotiated and is expected to commence on 1 July 2015.

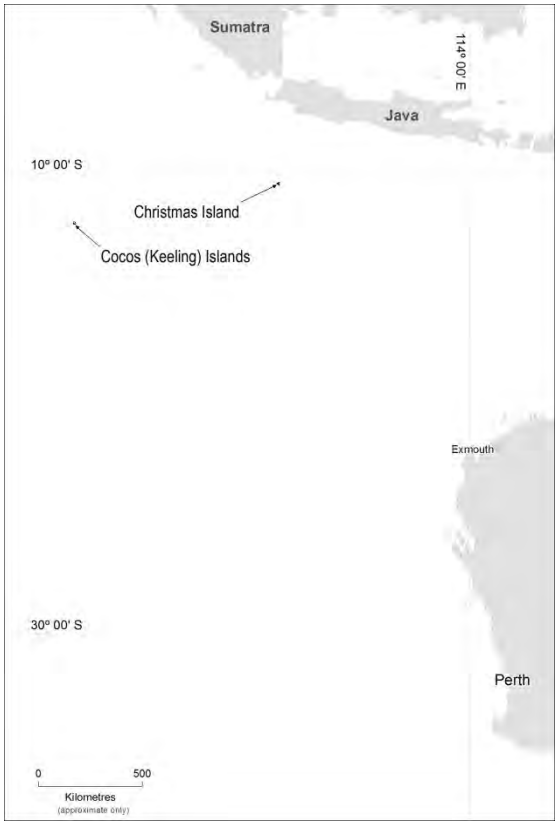
Subject to a new Service Delivery Arrangement being entered into, the island-specific recreational fisheries management arrangements for the Indian Ocean Territories will be progressed to legislation.

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

1 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.

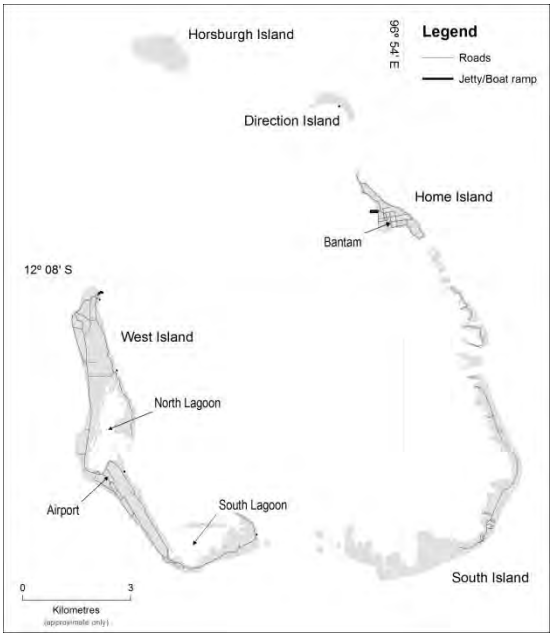
External Factors

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.



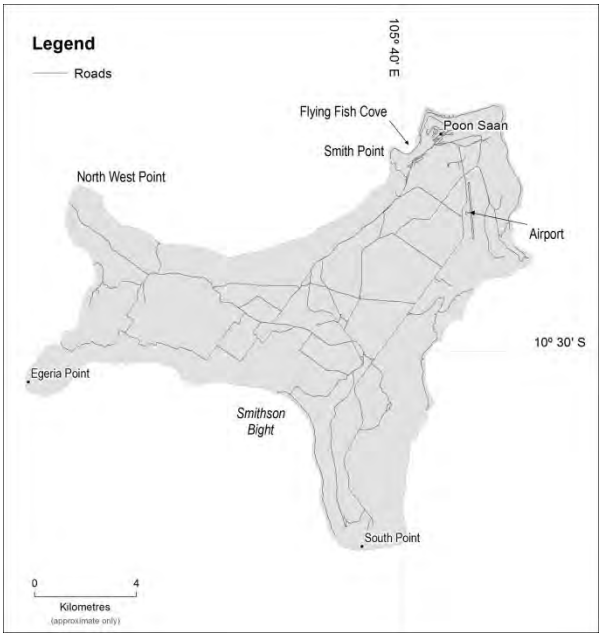
INDIAN OCEAN TERRITORIES FIGURE 1

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 2014 the FAL processed and aged 15,543 fish (Finfish Ageing Laboratory Table 1). This was about 14% fewer than 2013, due to a temporary reduction in staff. The priority species were from the Inshore Demersal Suite of the West Coast Bioregion, representing approximately 52% of fish aged. This group has steadily come to dominate the output of the FAL since reporting commenced in 2010, constituting 25%, 25%, 35%, 42% and 52% of output in 2010, 2011, 2012, 2013 and 2014 respectively, a reflection of the priorities of the of the Finfish Research Branch. While this proportion is expected to decline in 2015, the West Coast Demersal Suite is set to remain a high priority in the future.

Demersal species from the South Coast Bioregion were also a high priority, supporting an age-based stock assessment project. State-wide, demersal species again dominated, representing 89% of the total FAL output.

A guide to methods for ageing key finfish species from the West Coast and South Coast Bioregions is currently being drafted by the Department of Fisheries. Chapters on Australian herring and blue morwong have been completed, forming a template for chapters on other species in various stages of completion. A northern guide will follow (for species in the North Coast and Gascoyne Coast Bioregions).

FINFISH AGEING LABORATORY TABLE 1.

The number of fish processed and aged by the Finfish Ageing Laboratory in 2014, by Bioregion, species, ecological suite and whether it is an indicator species for that suite.

West Coast Bioregion	Number processed	Ecological suite	Indicator species
Australian herring Arripis georgianus	918	Nearshore	Yes
West Australian Dhufish Glaucosoma hebraicum	2,118	Inshore demersal	Yes
Pink Snapper Pagrus auratus	2,124	Inshore demersal	Yes
Baldchin Groper Choerodon rubescens	1,089	Inshore demersal	Yes
Redthroat emperor Lethrinus miniatus	1,515	Inshore demersal	Yes
Bight Redfish Centroberyx gerrardi	1,201	Inshore demersal	Yes
Total	8,965		
Gascoyne Bioregion	**Number processed**	**Ecological suite**	**Indicator species**
Pink snapper Chysophrys auratus	173	Inshore demersal	Yes
Yellowfin whiting Sillago schomburgkii	728	Nearshore	Yes
Total	901		

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

North Coast Bioregion	Number processed	Ecological suite	Indicator species
Rankin cod Epinephelus multinotatus	14	Inshore demersal	Yes
Goldband jobfish Pristpomodides multidens	32	Inshore demersal	Yes
Red bass Lutjanus bohar	122	Inshore demersal	No
Total	168		
South Coast Bioregion	**Number processed**	**Ecological suite**	**Indicator species**
Pink Snapper Pagrus auratus	781	Inshore demersal	Yes
Bight Redfish Centroberyx gerrardi	2,309	Inshore demersal	Yes
Blue morwong Nemadactylus valenciennesi	1,843	Inshore demersal	Yes
Total	4,933		
Statewide	**Number processed**	**Ecological suite**	**Indicator species**
Hapuku Polyprion oxygenios	25	Offshore demersal	Yes
Blue Eye Trevalla Hyperoglyphe antarctica	36	Offshore demersal	Yes
Ruby snapper Etelis carbunculus	515	Offshore demersal	Yes
Total	576		
GRAND TOTAL	15,543		

Activities of the Marine Biosecurity Research Group during 2014/15

Marine Unit

The Marine Biosecurity Research Group currently monitors high risk sites 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, certain species 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 and between Australian jurisdictions, 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 ocean going vessels that transport these goods represent one of the largest vectors of introduced species. In 2014 alone there were over 28 000 visits to Western Australian ports from commercial ships. For these reasons of propagule pressure alone our ports and marinas are regarded as high risk areas for the potential introduction of a marine pest. The Commonwealth Government, together with the states and territory has 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 Group are 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 at HMAS Stirling (Garden Island, Defence Services Group) in late 2014 and in Fremantle and Dampier Ports in early 2015. The Marine Biosecurity Research and Monitoring Group have also developed more risk-based targeted monitoring programs, to complement the above, which occur in the off years.

The Marine Biosecurity Research Group have developed 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 for marine pest monitoring in Broome, Port Hedland, Cape Lambert, Dampier, Cape Preston, Fremantle, Albany, Esperance and at HMAS Stirling (Introduced Pests Figure 1). 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. In December 2014 another specimen of *C. japonica* was caught by a recreational fisher in the Swan River Estuary and handed in to the Department. A further week of surveillance trapping was conducted, totalling more than 8,000 trap hours. No further specimens were detected during the surveillance trapping, nor were there any more handed in by members of the 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 Group who have since detected the species 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 expansions 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 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 Group has developed identification capabilities for this species based on characterisation of its DNA. Samples of *D. perlucidum* from around the world were analysed to investigate the native and introduced range of this species. We identified that populations of *D. perlucidum* elsewhere had multiple genetic COI haplotypes where as in Australia we consistently find

only a single COI haplotype. Native populations of a species typically have the highest genetic diversity. The low diversity present in Australian samples suggests these populations are introduced. Finer scale microsatellite analyses of these Australian samples revealed several populations to be distinctly different from others indicating multiple introductions of this species to 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 has been prolific elsewhere and once established readily spreads throughout its new location. In 2014 the Marine Biosecurity Research Group undertook a delimiting survey of this species in and around the vicinity of the Albany tug pen where it had previously been reported. The algae was confined to the same area it originally occupied in 2008 (approximately 4m wide by 80 m long) and was extremely patchy in its distribution. As this species did not appear to be displaying the invasive traits we may have expected based on the literature a control program was initiated to try and reduce the biomass. Divers removed all visible plants, taking care to capture all visible material to avoid spread. *Codium fragile* ssp *fragile* is known to be able to regrow from remnant tissue therefore every effort was made to remove as much visible material as possible. In early 2015 the team returned to Albany to ascertain if there was any regrowth after the removal. Although the alga was still present, biomass was significantly reduced despite the field period being during peak growth time for this species. It is believed that remnant cells from the holdfast may have regrown to produce the existing plants. New trials will be undertaken to test removal and spot treatment (using chemo-mechanical treatments) of holdfast scars underwater. The learnings from this study are not limited to *Codium* but broadly applicable to the control of any sessile pest species. It is hoped that with sufficient attention we may be able to remove this species from WA waters.

Research programs

Temporal likelihood analysis

The Marine Biosecurity Research Group is undertaking a large spatial and temporal analysis of vessels entering WA ports and how vessel activity and risk has changed over time from 2002 to 2014. This research examines 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 will provide an analysis of the changing patterns in trade to better manage domestic and international biosecurity risks to Western Australia

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 Group has commenced a study of recreational vessels from marinas all over the State. This has three main components. Firstly a state-wide survey of vessel owners examining vessel use and maintenance practices. Then in the West Coast Bioregion 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 thirdly 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.

Wrapping structures

Preventative measures such as maintenance of a clean vessel hull are widely acknowledged as more effective in curtailing invasions of marine pests than are eradication or control measures. The Marine Biosecurity Research 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 group are now undertaking a project that will provide accurate data correlating length of time a structure is wrapped with biofouling breakdown and mortality under different seasonal environmental conditions. By providing more comprehensive timeframes associated with wrapping efficacy this will increase the level of confidence when using this method to deal with marine pest emergencies.

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 using underwater cameras to examine 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 2013/14

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 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 surveillance project the Marine Biosecurity Research Group completed a large-scale marine pest monitoring program in Christmas Island port in early 2015.

INTRODUCED PESTS FIGURE 1.

Map showing the locations of the early warning system monitoring program around Western Australia.

Activities of the Freshwater Biosecurity Research Program 2014

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

Background

In 2010, an NRM funded project surveyed 114 of over 4000 permanent wetlands of the Swan Coastal Plain between Geraldton and Busselton. This project found that fish abundance in the majority of wetlands surveyed was dominated by introduced species. The survey detected two new introduced fish species and a new location for a previously detected introduced species. Findings from this survey identified the need for a more comprehensive survey program.

As a result, a detailed survey of pest fish in metropolitan water bodies commenced in 2012. The 2012 and 2013 results have been reported previous annual reports. Prior to 2014 there were three introduced crustacean species and 19 introduced finfish species recorded in freshwater in Western Australia (WA) (excluding species stocked for recreational angling (Freshwater Biosecurity Table 1). Most of these species show evidence of successful reproduction through the presence of multiple year classes and are therefore considered established pests. Murray cod, golden perch, silver perch and the convict cichlid do not appear to have established self-sustaining populations, however, this does not necessarily imply they are unable to breed in WA.

Freshwater fishes are one of the most commonly introduced vertebrate species. Ornamental fish in particular account for the 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. Many of these species can negatively impact both native species and the ecosystem as a whole.

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 aquaponics) and the aquarium trade. Many species are approved for translocation within the state, these are recorded in industry specific "White List". Species not on a "White List", need to be assessed for risk. If the assessment determines that the translocation of that species into or within WA is acceptable, translocation approval is granted with a set of conditions that must be followed. Applications are refused when the risk is assessed as being too high.

Community Engagement

The Department has continued to have a strong focus on community engagement. The 'don't dump that fish' program launched in 2013 has continued with the distribution of posters, brochures and fish bag stickers that alert aquarium owners to the environmental dangers of dumping unwanted fish into open waterways, toilets, drains or the ocean. In 2014, WA PestWatch, a free smart phone and tablet application ('app') that allows members of the public to report sightings of pests in the field, was upgraded. The new upgrade includes more photos of marine and freshwater pests that are currently in WA, or have a potential to be a pest here. This allows users to more easily recognise pest species and report them via the app.

The Department has attended several community events in the metropolitan and regional areas, as well as visiting aquarium shops and other relevant outlets to distribute freshwater biosecurity materials. Compliance officers have continued to conduct random inspections at the Perth airport in an attempt to prevent any species entering WA that are not listed on the allowable import list, or are seen as a high biosecurity threat.

The Department's research staff, policy staff and enforcement staff involved in biosecurity have received formal training in incident management so that there is a readiness 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.

Pest Reporting and Response

In addition to the ongoing survey work conducted throughout the Perth-metro region (Swan/Canning coastal plain) in 2014, the Freshwater Biosecurity Research Unit also responded to several 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 perceived risk and previous known distribution of the reported species. From the 45 reports received in 2014, eight were responded to 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.

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 2014, a continuation from the 2012 and 2013 monitoring, was concentrated in the Perth metropolitan region of the Swan/Canning coastal plain. This area has been identified as high risk due to previous pest fish detections, the high population density and the extensive lake and drainage systems connected to the Swan and Canning Rivers.

There are approximately 1300 permanent wetlands listed in the Perth-metro region, comprised of natural lakes and swamps, man-made or highly modified lakes, water compensation basins as part of drainage management, and permanent pools in ephemeral systems. A review of recent late summer aerial photos indicated that only approximately half of the listed permanent wetlands currently retain water all-year-round.

Sampling for this survey was commenced by the Freshwater Biosecurity Research Unit in 2012. Sampling priority was given to wetlands closest to previously reported pest species populations. Occasionally, site visits revealed the location was not able to be sampled as it was either 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 wetlands were sampled.

Sampling methodology

The majority of sampling in the Perth area in 2014 was undertaken using fyke nets – a fish trap that has a wing attached to the bank, which guides fish into a series of hoops and funnels from which they are unable to escape. These nets were generally unbaited. It is accepted that not all fish species are susceptible to capture by fyke nets, however, it was considered the most appropriate, cost effective method for sampling the large number of locations in this survey. Fyke nets can also be used in locations where other methods such as seine netting, electrofishing, gill nets and opera house traps are unable to be deployed due to habitat type, by-catch and staff safety. However, on occasions, these 'other' methods were utilised where required. The fyke nets used by the Department were fitted with a float ring to ensure any air-breathing animals captured in the nets could access the air above the water surface.

Survey Results

A total of 157 sampling events were conducted during the 2014 survey, at 114 locations (Table 2). In October 2014, a report from the public was received through Fishwatch alleging that Murray cod, *Maccullochella peelii peelii* were breeding in a lake adjacent to Alexandria Boulevard, Canningvale. A follow up visual survey conducted by the Department confirmed the Fishwatch report, with the sighting of one Murray cod in the lake, however, there was no evidence at that time of breeding. The Department then unsuccessfully deployed fyke nets in an attempt to catch the Murray cod. Boat based electrofishing was subsequently undertaken by staff from Murdoch University, where they captured one Murray cod and sighted, but were unable to land, a second Murray cod.

Murray cod have been stocked into many public and private waters outside its natural range, including at a number of localities in south-western Australia in the late 1800s (i.e. the Swan-Avon River and Lake Powell - formally known as Lake Grassmere, Albany). However, there is no information to indicate these populations still exist.

In a separate incident, the Freshwater Biosecurity Research Unit received an email from the Turtle Oblonga Rescue Network in August 2014, reporting the freshwater eel-tailed catfish *Tandanus tandanus* to be present at a water-filled clay pit in Kalamunda National Park, Gooseberry Hill. This report came as the third location the eel-tailed catfish was recorded in the Perth-metro region. Initial sampling of the clay-pit lake captured three catfish which were later confirmed to be *Tandanus tandanus*. Further sampling of the location removed an additional 47 of the catfish. The clay-pit lake overflows into a creek line which feeds into Helena Valley

Pipehead Dam. Sampling of the Helena River above this dam and the dam itself was conducted by the Department, but failed to capture any *T. tandanus*. The native freshwater cobbler *Tandanus bostocki* was, however, captured during this sampling occasion. The connectivity of the clay-pit lake to the Pipehead Dam is of particular concern. For instance, if *T. tandanus* enters the dam it would likely follow overflow linkages directly into the Swan River.

Control and Containment Activities

The Freshwater Biosecurity Research Unit continued with control measures in 2014 for the population of *T. tandanus* in Marmion Reserve Lake, Myaree. A final fish-down effort was conducted in January 2014, which removed over 460 Catfish from the lake prior to undertaking the poisoning of any remaining *T. tandanus* with the fish poison rotenone in mid-February 2014. Four post-poisoning surveys were undertaken that captured a total of 14 young-of–the-year *T. tandanus*, and so a second round of rotenone poisoning was undertaken in November 2014. The Freshwater Biosecurity Research Unit has continued to undertake follow-up sampling on *T. tandanus* at Ollie Worrell Reserve, and over six sampling occasions throughout 2014 has captured only one additional *T. tandanus*. This site will continue to undergo monitoring.

The capture of Pearl Cichlids, *Geophagus brasiliensis*, in wetlands adjacent to the Southern River led to concerns about the potential of this species to cross into the Serpentine Catchment via the Berriga Drain located on the Wungong Brook. During 2014 the Department of Fisheries worked with the Department of Water, Water Corporation, Swan River Trust, Serpentine – Jarrahdale Shire and the land owner through which the drain flowed to close this connection and prevent the spread of this pest species into the Serpentine and Peel-Harvey systems.

New Discoveries

Two of the eight reports (excluding the introduced catfish and Murray cod above) which were attended to in the Perth-metro region were of particular importance to the Freshwater Biosecurity Research Unit.

A report of an unidentified dead fish found on the banks of a lake in Kingsbridge Boulevard Lake, Butler, was received by the Department via phone. The species was identified to be an Oscar, *Astronotus ocelltus* or *crassispinis*, which is the first record of this species in WA. Sampling of the lake failed to catch any further Oscar specimens.

The second report of particular importance to the Department was of an eel-like species, which had allegedly been observed in a lake at Sir James McCusker Park. Sampling was conducted twice at the site of the report, but failed to capture any eel-like species. However, the ongoing survey captured one Marbled Eel, *Anguilla reinhardtii*, in a small lake in Hillarys which was the first capture of this east coast species in WA.

Impact on non-target species

The use of fyke nets for sampling can unintentionally capture non-target species. The most commonly caught non-target species was oblong turtles *Chelodina oblonga*. A total of 1,581 oblong turtles were caught in the 5,702 fyke nets set during the 157 sampling occasions conducted in 2014. All of these animals were returned alive to the water. Water birds were also captured in shallow wetlands sampled, where the entrance to fyke nets was not completely submerged under water. A total of 16 water birds were captured at eight sites, and all but two were released unharmed. A musk duck became entangled in the rope structure inside the fyke and a second musk duck was captured in a gill net set.

Native fish abundance

Native fish abundance recorded from the 2014 sampling displayed a similar trend to that observed during the 2012 and 2013 survey. Of the 114 wetlands sampled, native species were found to be present in only 39 sites (34%). Far less wetlands were found to contain *only* native freshwater species (1%). The majority of the sites surveyed contained introduced *and* native species or *only* introduced species. There is little historical information on native fish distribution in the wetlands of the Perth metropolitan region. Low frequency and abundance of native species may be the result of reduced water levels from decreased rainfall and/ or increased groundwater extraction, poor water quality (i.e. acidification, eutrophication, salinisation, sedimentation as well as pollution by industrial, residential and agricultural waste), destruction of riparian vegetation, channelisation of streams in irrigation areas, or introduced species which can compete with and prey on native fish.

FRESHWATER BIOSECURITY TABLE 1

Freshwater species introduced to Western Australia, recorded during the Freshwater Biosecurity Survey (2010-2014)

Common Name	*Scientific Name*	Origin	Year of Introduction (Detection)
Finfish			
Carp (Koi)	*Cyprinus carpio*	Eurasia	1947
Convict Cichlid	*Amatitiania nigrofasciata*	Central America	(2011)
Freshwater Eel-tailed Catfish	*Tandanus tandanus*	Eastern Australia	(2010)
Gambusia/ Mosquito Fish	*Gambusia holbrooki*	Sth America	1934
Golden Perch	*Macqaria ambigua*	Eastern Australia	1897
Goldfish	*Carassius auratus*	Eurasia	1893
Guppy	*Poecilia reticulata*	Sth America	(2001)
Murray Cod	*Maccullochella peelii peelii*	Eastern Australia	1894
Pearl Cichlid	*Geophagus brasiliensis*	Sth America	(2006)
Redfin Perch	*Perca fluviatilis*	Europe	1903
Rosy Barb	*Puntius conchonius*	SE Asia	(2007)
Silver Perch	*Bidyanus bidyanus*	Eastern Australia	1897
Southern Platyfish	*Xiphophorus maculatus*	North and Central America	(2013)
Spangled Perch	*Leiopotherapon unicolor*	Gascoyne	(2009)
Speckled Mosquito Fish	*Phalloceros caudimaculatus*	Sth America	(1972)
Swordtail	*Xiphophorus helleri*	Sth America	(2001)
Tilapia	*Oreochromis mossambicus*	Africa	(1978)
Marbled Eel	*Anguilla reinhardtii*	Eastern Australia	(2014)
Oscar	*Astronotus ocelltus or crassispinis*	Sth America	(2014)
Crustaceans			
Redclaw Crayfish	*Cherax quadricarinatus*	Eastern Australia	(2000)
Yabby	*Cherax destructor albidus*	Eastern Australia	1932
Indistinct River Shrimp	*Caridina indistincta (B1)*	Eastern Australia	(2013)
Molluscs			
Snail sp.	*Planorbella sp*	Unknown	(2013)

FRESHWATER BIOSECURITY TABLE 2

Freshwater Biosecurity Sampling Results from the Perth-metro Region

Year of Sampling	2014		2013		2012	
	Total	%	Total	%	Total	%
Finfish						
Number of locations visited	114	-	176	-	140	-
Number of locations by visit dry or too shallow	2	2	8	5	9	6
Number of locations sampled	105	92	164	93	124	95
Number of locations containing finfish	92	81	134	76	119	96
Number of locations containing Estuarine fish	28	25	33	19	42	34
Number of locations containing native freshwater finfish	39	34	17	10	8	6
Number of locations containing only native freshwater finfish	2	2	0	-	3	2
Number of locations containing feral freshwater fish	89	78	126	72	99	80
Number of locations containing only feral freshwater finfish	74	65	49	29	71	57
Number of new introduced finfish species detected	2	2	2	1	1	<1
Number of new locations introduced Tandanus tandanus detected	1	<1	1	<1	0	-
Number of new locations introduced Leiopotherapon unicolor detected	0	-	1	<1	8	6
Number of new locations introduced Xiphophorus helleri detected	6	5	3	2	NA	NA
Crustaceans						
Number of locations containing crustaceans	63	55	85	48	66	53
Number of locations containing native crustaceans	38	33	63	36	51	41
Number of locations containing only native crustaceans	30	26	3	2	29	23
Number of locations containing feral crustaceans	33	29	45	26	37	30
Number of locations containing only feral crustaceans	24	21	4	2	14	24
Number of new introduced crustacean species detected	NA	NA	1	<1	NA	NA

NA not applicable for this year of sampling

FRESHWATER BIOSECURITY FIGURE 1

2014 Freshwater Biosecurity Sampling Locations in Perth-metro region.

Monitoring of the Southwest artificial reef trial in 2013 & 2014

P. Lewis & M. Pagano

The Department of Fisheries (Department) first trial of purpose built artificial reefs in Western Australia began in March 2013 with the deployment of 60 artificial reef modules at two locations in Geographe Bay. 30 of the reinforced concrete modules (SW Artificial Reef Trial Figure 1) are located at each reef site off the Bunbury and Dunsborough (SW Artificial Reef Trial Figure 2). The $2.38 million Southwest artificial reef trial (Artificial Reef Trial) was funded by Royalties for Regions and Recreational Fishing Initiatives Fund which is funded through Recreational Fishing Licences. The funding included provisions for 4 years of monitoring of the trial. A monitoring plan for the Artificial Reef Trial was designed and overseen by a Scientific Reference Group (made up of members from the Department, Recfishwest and other Research Institutes in WA) and meets the requirements for the Commonwealth Department of the Environment (DOTE) approvals. Full details of the monitoring are covered in the Long Term Management and Monitoring Plan for the Artificial Reef Trial, available on the Department website. The monitoring conducted each year and results are summarised in an annual report produced in July each year for the DOTE.

Monitoring Objectives

The monitoring objectives are divided into four broad groups (see below). The Department is responsible for the first three of these and provides input to the monitoring of the fourth by Recfishwest.

The monitoring objectives are:

Biological

- Document the use/colonisation of artificial reefs by recreationally important fish species, noting concentration and production effects. How and why are fish using these structures?
- Document the presence of any protected species in proximity with the artificial reefs,
- Document the presence of any introduced species in proximity with the artificial reefs.

Ecological

- Describe the extent of the influence of the artificial reefs on recreationally important fish species in the area.
- Assess the impacts of artificial reefs on proximal reef communities with comparisons to (potentially) HMAS Swan, MV Lena, natural reefs and Busselton Jetty (NB – existing data for the HMAS Swan and Busselton Jetty already exist).

Artificial Reef Structures

- Document changes to the artificial reef modules post-installation including movement, integrity (e.g. cracking, rusting).
- Document changes to areas immediately around the artificial reefs post-installation including scouring, sedimentation, and benthic habitat types etc.

- Document any other anthropogenic changes such as fouling of fishing gears and anchors, and remove to reduce risks.

Social/ Economic (conducted by Recfishwest)

- Document the use of the artificial reef areas by recreational fishers.
- Document fishing activities (effort and catch) on artificial reefs. Compare to available data to identify changes in recreational angler behaviour (catch, effort etc).
- Document reasons why fishers use the artificial reefs.

Biological, Ecological and Structural monitoring methods

The Department monitoring surveys are conducted using a combination of baited remote underwater video (BRUVs), diver operated video (DOV), towed underwater video (TUV) and sidescan sonar to assess the monitoring objectives at:

- Artificial reef sites,
- Control sites (close <1 km and distant >5 km natural reef sites),
- Surrounding natural reef sites (areas of natural reef at intervals of approximately every kilometre up to 6 km from the artificial reefs).

The monitoring plan includes:

- An annual major survey in February of all sites above; and
- Additional minor seasonal surveys (May and September/October) of the artificial reef and control sites for the first 2 years using methods appropriate at the time, accounting for weather and water visibility restrictions.

The stereo video systems used allow the lengths of the target species and other recreationally important species to be estimated from the footage.

Monitoring conducted

Seven surveys of the Artificial Reef Trial and surrounding natural sites were conducted during 2013 & 2014 (SW Artificial Reef Trial Table 1).

On each survey it was possible to achieve the minimum BRUV drops and sidescan sonar surveys required (SW Artificial Reef Trial Table 1). However, it was not always possible to dive at the Bunbury Reef due to limited visibility (< 1 metre) at times.

The shift in timing of the major annual survey from May to the February period should coincide with better visibility at both Reefs and allow diver surveys at Bunbury to be undertaken. This will allow the structural integrity and debris monitoring required to be achieved.

Biological and Ecological monitoring

Fish species recorded on the artificial reef sites

The pre-deployment BRUV surveys at the artificial reef sites recorded a diversity of 10 and 12 species at the Bunbury and Dunsborough sites, respectively. Of the target species Samsonfish (*Seriola hippos*), Snapper (*Chrysophrys auratus*) and silver trevally (*Pseudocaranx georgianus*) only Snapper were recorded at the Dunsborough site and silver trevally at Bunbury site on these surveys, both in low numbers (n=1 to 3).

The Bunbury and Dunsborough Reefs show signs they are still establishing with the diversity and relative abundance of fish on both reefs generally increasing over the first 18 months, with slightly lower values at 6 and 13 months due to the influence of low visibility, see Figures 3 and 4. The post deployment BRUV surveys have recorded total cumulative diversity of 38 and 44 fish species at the Bunbury and Dunsborough Reefs, respectively. These include all three target species on both Reefs, albeit in low abundance apart from Samsonfish on the Dunsborough Reef which occurred as a consistent school of 30-50 fish.

No protected or introduced species have been recorded on or in the vicinity of the Bunbury and Dunsborough Reefs.

Fish species recorded on surrounding natural reef sites

The post deployment BRUV surveys recorded a total of 105 and 110 fish species on the surrounding natural sites in the vicinity of the Dunsborough and Bunbury Reefs, respectively. The surveys have recorded baseline and seasonal data on the abundance and size of the three target species (snapper, Samsonfish and silver trevally) and other recreationally caught finfish species in these surrounding areas.

Structural monitoring

The sidescan sonar survey conducted at deployment confirmed that all of the modules at both the Bunbury and Dunsborough Reefs had been placed within the site boundaries specified to DOTE. All post deployment sidescan sonar surveys have indicated no movement of the modules.

During 2013 a significant storm event occurred with a maximum wave condition of significant wave height (Hs) =9.47 m (with 9.2 m swell and 2.3 m sea) and wave period (Tp) = 16.67s recorded at the Cape Naturaliste waverider buoy on the 1st of September 2013 (Dept. of Transport *pers comm*). This storm event was approaching the intensity of the 1/100 yr storm calculated as Hs = 10-11 m, Tp = 16-20 s for a location offshore of Busselton (50 m water depth), based on extreme analyses of NOAA Wave Watch 3 model. It also exceeds the maximum Hs = 8.2 m recorded in the period from 2007-2011 at Cape Naturaliste. Thus the modules at the Bunbury and Dunsborough Reefs have withstood a significant storm event in their first six months with no signs of movement or damage.

The diver surveys detected some bedding down of the modules into the sediment at the Bunbury and Dunsborough Reefs. Some small scale scouring and deposition of sediment in the vicinity of modules was also evident but not to any significant distance, less than 2 m.

The diver surveys removed three and two lengths of fishing line with hooks, sinkers or lures that were wrapped around modules at Bunbury and Dunsborough Reefs respectively. An anchor with 10 m of rope was also removed from the Bunbury Reef.

Extension activities

The project has a produced a number of seminars and articles for recreational fishers. The Long Term Management and Monitoring Plan, plus data, pictures, video footage and other information collected during the Artificial Reef Trial has been incorporated into the artificial reef information page on the Department website (http://www.fish.wa.gov.au/Fishing-and-Aquaculture/Recreational-Fishing/Pages/Artificial-Reefs.aspx). The project has assisted with ministerial media releases and associated pictures and video for the official opening in April 2013 and at the 12 month anniversary. These resulted in numerous articles on the Artificial Reef Trial in the media, particularly in the south west of Western Australia.

Additional activities included meeting with Recfishwest and the Mandurah Offshore Fishing Club to provide advice on the approvals process for the proposed Mandurah artificial reef, meeting with honours students (on socio-economic assessment of the artificial reefs and citizen science monitoring), involvement in a collaborative FRDC proposal and subsequent FRDC project (2014/005) with Recfishwest on habitat enhancement structures in WA involving two PhD students.

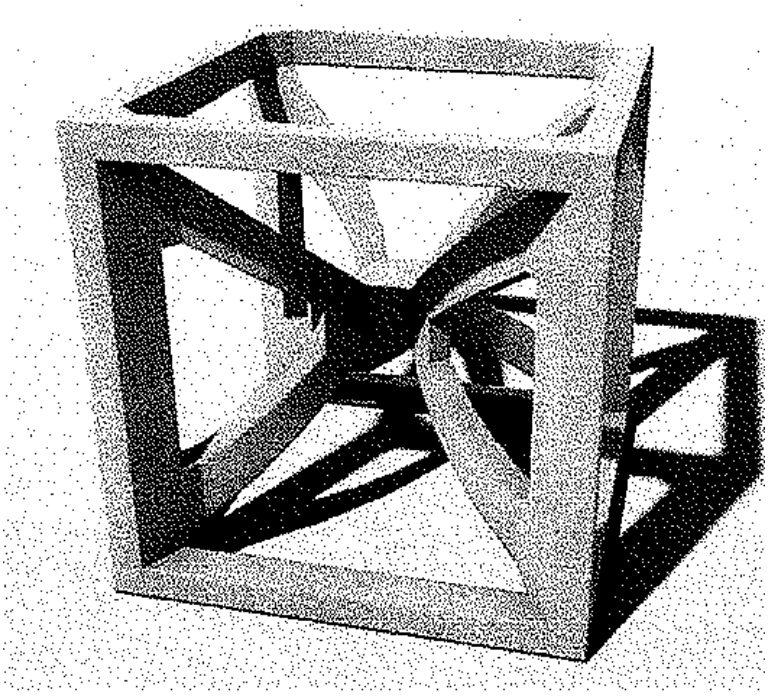
Ongoing monitoring

The funding for the monitoring of the Artificial Reef Trial allows for further major surveys to be conducted until 2017. At the end of this monitoring period a full report on the monitoring objectives will be produced for the Artificial Reef Trial.

SW ARTIFICIAL REEF TRIAL TABLE 1.

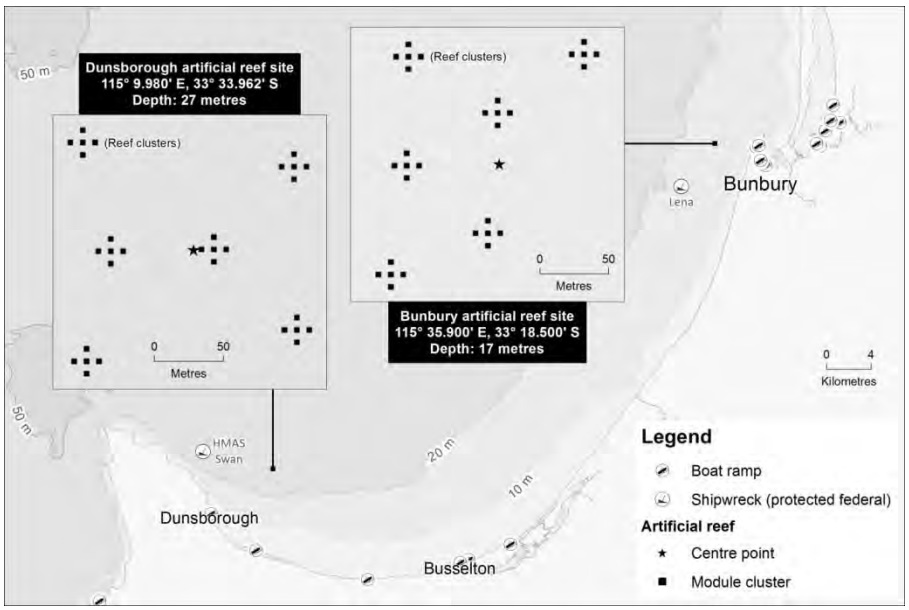
Details of date, reef age and type for each survey conducted in the SWART, giving monitoring conducted for each method (number of drops or transects) at each artificial reef. (BRUV – baited video and TUV – towed video).

Date	Reef age	Survey	Bunbury				Dunsborough			
			BRUV	Dive	Sonar	TUV	BRUV	Dive	Sonar	TUV
Jan 2013	Pre	Minor	9	-	4	6	9	-	4	6
Apr 2013	0	AR only	-	-	2	2	-	-	2	2
May 2013	1	Major	58	-	2	-	55	4	2	-
Sep 2013	6	Minor	9	-	2	-	9	4	2	-
Jan 2014	10	Major	50	9	2	-	50	4	2	-
May 2014	13	Minor	9	-	-	-	9	4	-	-
Oct 2014	18	Minor	9	-	2	8	9	-	2	8



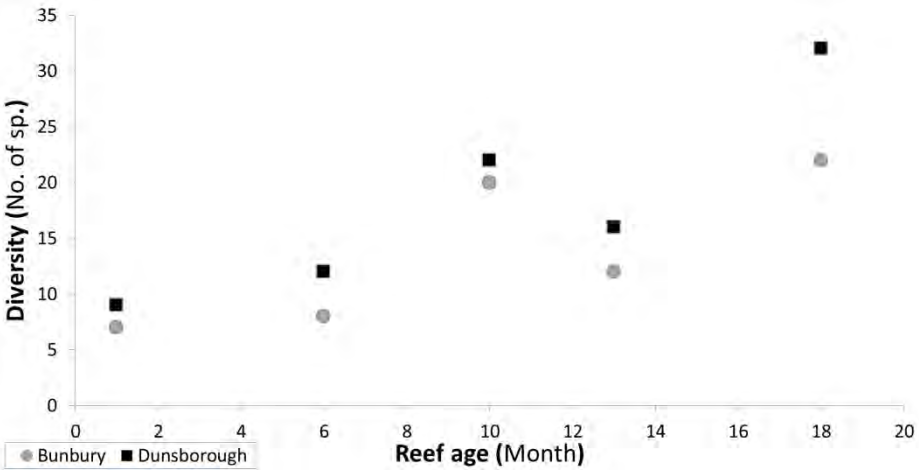
SW ARTIFICIAL REEF TRIAL FIGURE 1.

Reinforced concrete fish box module used in the Artificial Reef Trial. Each side is approximately 3 m. Each unit weights approximately 10 t.



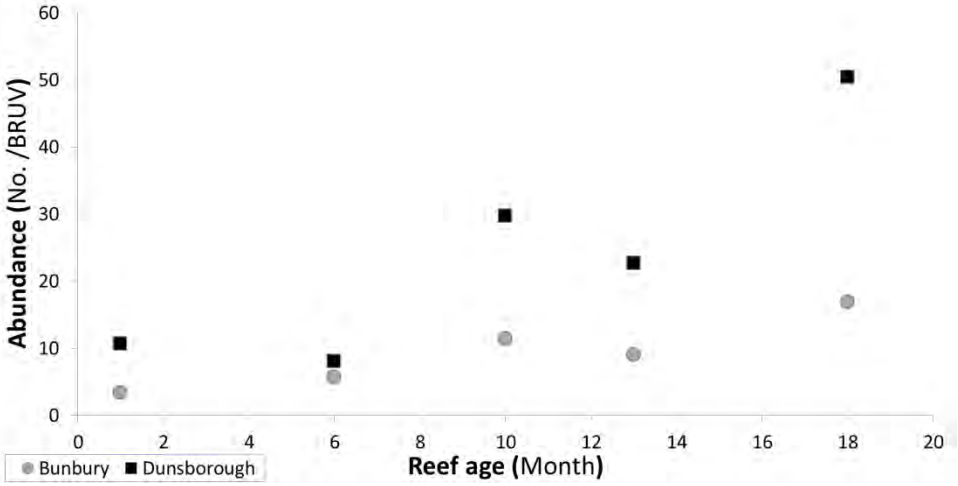
SW ARTIFICIAL REEF TRIAL FIGURE 2.

Map of Geographe Bay in southwestern WA showing artificial reef trial sites with coordinates and showing layout of modules at each site.



SW ARTIFICIAL REEF TRIAL FIGURE 3.

Diversity of fish species (No. of species) recorded on each survey of the Bunbury and Dunsborough Reefs over the first 18 months.



SW ARTIFICIAL REEF TRIAL FIGURE 4.

Relative abundance of fish (Average No. of fish/BRUV) recorded on each survey of the Bunbury and Dunsborough Reefs over the first 18 months.

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 2013/14 season or the calendar year 2014 for fisheries data but up to June 2015 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 2013/14 or 2014	Comment
Fishery: Abalone *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* August 2004 *Current accreditation*: August 2015 *Expiry date:* August 2025	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:* August 2015 *Expiry date*: August 2025	Scallops (spawning stock)	The survey stock abundance index determines a predicted catch that sets the length of the next season and the fishing season ceases at a catch rate threshold level,	Environmentally Limited	The survey catch prediction was below the target range therefore the fishery did not open in 2014 due to low stock levels

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
Fishery: Beche-de-mer *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* December 2004 *Current accreditation:* August 2011 *Expiry date:* August 2016	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	
Fishery: Broome Prawn *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* August 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	Western king prawn (spawning stock)	Annual exploitation rate of king prawns to not exceed 60% in any one year	Acceptable	No fishing in 2014.
	Coral prawns (spawning stock)	Total catch within acceptable range of 20–90 t (7-year catch range)	Acceptable	As above
Fishery: Exmouth Gulf Prawn *Approval Type:* Accredited Export Exempt Fishery *Initial accreditation:* March 2003 *Current accreditation:* August 2015 *Expiry date:* August 2025	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 above target level.
	King prawn (spawning stock)	Total catch within acceptable range of 350–500 t	Acceptable	Below range but the catch prediction was low and landings were just above the prediction range with a conservative fishing 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: Gascoyne Demersal Scalefish Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* June 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	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 details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
Fishery: Kimberley Prawn *Approval Type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	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:* August 2015 *Expiry date:* August 2025	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: Northern Demersal Scalefish *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	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 details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
Fishery: Onslow and Nickol Bay Prawn *Approval Type:* Accredited Export Exempt Fishery *Initial accreditation:* November 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	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	Limited fishing by one boat in 2014.
	Brown tiger prawn (spawning stock)	Acceptable catch ranges of Nickol Bay 2–40 t and Onslow 10–120 t	Acceptable	As above for Onslow.
	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. Limited fishing in 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:* August 2015 *Expiry date:* August 2025	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: 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	

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
	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
	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:* August 2015 *Expiry date:* August 2025	Western Australian salmon (spawning stock)	Expected catch range under the current management regime is 1,200–2,800 t	Acceptable	2014 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 details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
Fishery: Shark Bay Crab Interim Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* November 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	Blue swimmer crab (breeding stock)	CPUE to remain above 1 kg/trap lift	Acceptable	Partial recovery of the stock during 2013 provided confidence to resume commercial fishing with a conservative TACC of 400 tonnes of which 93% was achieved. Ongoing stock monitoring surveys indicates increasing levels of recruitment and spawning biomass during 2014.
Fishery: Shark Bay Prawn *Approval type:* Accredited Export Exempt Fishery *Initial accreditation:* February 2003 *Current accreditation:* August 2015 *Expiry date:* August 2025	Tiger prawn (spawning stock)	Level of spawning stock present based on fishery independent surveys during the spawning season at a target of 25 kg/hr (5.5 fathom quad gear)	Acceptable	The spawning stock was within the target. An additional area is being assessed as a spawning area and a combined Index will be used in future.
	King prawn (spawning stock)	Total catch within historical acceptable range of 1,100–1,600 t, given no change in effort	Acceptable	
	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 2014 season, 27 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	

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
	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:* August 2015 *Expiry date:* August 2025	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	Environmentally Limited	Catch prediction below target level due to poor environmental conditions and the fishery did not open In 2014.
	Loggerhead turtles (captures)	90% of turtles captured from non-BRD nets returned alive	Acceptable	As for Shark Bay prawn although no fishing effort in 2014.
Fishery: South Coast Crustacean *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* September 2004 *Current accreditation:* November 2015 *Expiry date:* November 2016	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:* August 2015 *Expiry date:* August 2025	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:* August 2015 *Expiry date:* August 2018	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 at the end of 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

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
	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: West Coast Rock Lobster *Approval Type:* Wildlife Trade Operation Exemption *Initial accreditation:* August 2002 *Current accreditation:* May 2013 *Expiry date:* May 2018	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%	Acceptable	The catch rate of octopus (incidental landings) is an indicator for this fishery. Currently the catch rate is based on a different measure to those in the past and cannot therefore be compared. This comparison will be reinstated once a new time series of landed octopus is developed
	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	Unacceptable	There were 6 confirmed whale entanglements in WRL gear during the 2014 humpback whale migration season. Mitigation measures have been implemented to reduce whale entanglements.

Fishery details	Issue/species	Performance measure/Condition	Current performance in 2013/14 or 2014	Comment
Fishery: West Coast Deep Sea Crustacean Managed Fishery *Approval type:* Wildlife Trade Operation Exemption *Initial accreditation:* March 2004 *Current accreditation:* August 2015 *Expiry date:* August 2025	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.
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).
	Masters supervision, University of Western Australia, supervises Kelly Rensing - " Spatial and Temporal Movement Dynamics of Four Commercially Important Shark Species in Western Australia "
	Honours co-supervision, Murdoch University, supervises Carissa King - " Investigating the movement patterns of sharks and the significance of potential shark predation attempts on bottlenose dolphins (*Tursiops aduncus*) in the waters of south-western Australia "
Samantha Bridgwood	Technical Advisor for IMarEST Biofouling Expert Management Group.
Cécile Dang	Adjunct Lecturer Associate, Faculty of Science and Engineering, School of Science, Department of Environment and Agriculture, Curtin University.
Simon de Lestang	PhD co- supervision, University of Western Australia, supervises Jean Dumas - 'Investigating sperm limitation in the Western Rock Lobster Fishery'.
	Honours co- supervision, University of Western Australia, supervises Michael Brooker - An examination of the fish assemblages found in the west coast bioregion of Western Australia'.
David Fairclough	Adjunct Senior Lecturer. School of Veterinary and Life Sciences, Murdoch University.
	Adjunct Senior Lecturer. Department of Environment and Agriculture, Faculty of Science and Engineering. Curtin University.
	Honours co-supervision, Natasha Prokop, Murdoch University, Genetic implications of a novel technique for culturing Australasian snapper (*Chrysophrys auratus*) from wild-caught eggs collected from Cockburn Sound, Western Australia.
	Honours co-supervision, Megan Cundy, Curtin University, A comparison of reef fish assemblages in different management zones in the Jurien Bay Marine Park
Rick Fletcher	Member, NSW Marine Estate Expert Knowledge Panel.
	Co-supervision Jenny Shaw. Knowledge and adaptation in coastal fishing communities. PhD, Curtin University.
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.

Staff Member	Position
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.
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.
Terry Miller	Adjunct Senior Lecturer, Centre for Sustainable Tropical Fisheries and Aquaculture, College of Marine and Environmental Sciences, James Cook University.
Brett Molony	Member of Marine and Freshwater Course Consultative Committee, Edith Cowan University.
	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, Fa.culty of Science and Engineering, Curtin University.
Karina Ryan	Adjunct Supervisor, Eric Aidoo "Spatial Modelling of Recreational Boat-Based Fishing in Western Australia". PhD, Edith Cowan University.
	Adjunct Supervisor, Eva Lai "Integrating multiple sources of data to construct a time series of recreational catch/effort for the West Coast Bioregion of Western Australia". PhD, Edith Cowan 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.

Staff Member	Position
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.