CURRENT MARINE RESEARCH IN THE NINGALOO MARINE PARK, 2007

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Cover photo: An array of fish and coral in the Ningaloo Marine Park, Gnaraloo, Shannon A. Armstrong, 2007.

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1. INTRODUCTION

The Ningaloo Marine Park (NMP) was established in 1987. Since that time there has been increased interest in the marine environment, within and adjacent to the NMP, including its unique and diverse ecosystems and communities. This interest has led to a significant increase in tourism and recreational use of the area as well as encouraged significant research effort on the biodiversity, oceanic processes and human impacts experienced by the NMP so that we might better understand and manage the Marine Park.

A 10-year Management Plan was approved in 1989 to ensure the long-term conservation and management of the NMP. A review of the NMP and its management plan was undertaken between 1999 and 2004 which resulted in an updated plan, approved in 2005 (the NMP Plan), and a number of modifications to the marine park, including an increase in sanctuary zones and a southward extension of the Park to Red Bluff on Quobba Station. At the same time, the State Government provided significant additional funding for the management of the NMP for capital expenditure ($1.2M one-off) and as recurrent funding ($2.6M pa). This recurrent funding included $0.5M pa to the Department of Fisheries (DoF) for sanctuary zone compliance and $2.1M to Department of Environment and Conservation (DEC), of which $0.6M pa was earmarked for marine research and monitoring.

The increased size, usage and consequent complexity of managing the NMP highlighted the deficiencies in the knowledge base needed to manage the marine park effectively into the future and ensure the valuable iconic status of Ningaloo Marine Park. The State Government responded by committing an additional $5M over 4 years for a marine research program that would address key management strategies outlined in the management plan.

The Ningaloo Research Program (NRP) was developed in 2005 through consultation with marine scientists and marine managers that would ensure that future decisions by the government would be based on sound scientific information. The focus of the NRP is on improving our understanding of the ecological resources within the NMP, the processes that support them and the effectiveness of monitoring programs and management strategies to ensure the preservation of these natural values.

Shortly after the NRP was confirmed, a collaborative research venture incorporating government, research institutions, universities and industry partners was formed in Western Australia – the Western Australian Marine Science Institute (WAMSI) to facilitate research that would underpin the conservation and sustainable management of WA's marine environment. The research program within WAMSI is divided into streams, one of which (Node 3) is defined as: ***Managing and Conserving the Marine State: 'best practice' management and underpinning science.*** This node deals specifically with marine biodiversity conservation and is led agency by the DEC. The NRP became the initial science plan for Node 3 of WAMSI, to be managed and implemented by DEC's Marine Science Program.

In 2005, the CSIRO launched the Flagship Collaboration Fund as part of its *Wealth from Oceans* Flagship program that focussed on the habitats, biodiversity, and socio-

economic aspects of the NMP. This research program, referred to as the Ningaloo Cluster, was designed to complement the NRP and to work collaboratively with WAMSI Node 3 in developing a broad management strategy evaluation modelling project that will incorporate ecological, social and economic objectives.

In addition to these large programs of research, there are numerous individual projects supported by regional government departments, various universities and research institutions. For example, NMP will be a reference site for the international Census of Marine Life Project, it has also been chosen to house a series of acoustic arrays through the Australian Tracking and Monitoring system and will benefit from dedicated research through AIMS funded by industry partners.

It is essential though, that with the broad array of research conducted at the NMP findings and outcomes are identified and channelled through the right sources so that the information will be recognised, integrated and used in future decision making for the Marine Park. It is therefore critical that there is some overall picture of this large body of research that will pull these elements together. As a part of the integration of the NMP research, the Marine Science Program with in the DEC has developed a database of research projects currently underway on the NMP. The first report on this database was presented in 2006 (Armstrong 2006).

This second report provides an update on the database now that it has incorporated the full range of research undertaken by WAMSI and the CSIRO Cluster. Overall, it seeks to clearly identify the large research programs and the numerous other projects that may well provide information to these programs or benefit from the data that is being collected. This report also seeks to identify the management strategies listed in the Management Plan for the NMP that are being addressed by this body of work so that future effort may be dedicated to fill in the gaps where management questions remain. A Ningaloo Marine Park Research and Monitoring Plan (RMP) was prepared by the DEC in 2005 which lists and references these management strategies in order of priority and the referencing system is used in the tables below (Appendix 1). An excerpt of the RMP with the references is in Appendix 1.

Every effort has been made to ensure that all relevant current and proposed marine scientific research projects have been included into this report. However, this document should be viewed as a working paper that will have information added to it regularly for existing projects and for new projects.

At this time there are approximately 80 research projects relevant to the conservation and management of NMP, including a number of subprojects from the larger research programs. There are an additional 9 proposed research projects and 16 programs undertaken by the DEC District Office.

Information for this report was sourced through the following:

- Referring to the previous report and database compiled by Shannon Armstrong, (Armstrong, 2006).
- Incorporating the science plan identified for Node 3 of WAMSI
- Incorporating the science plan identified for the CSIRO Ningaloo Cluster

- Contacting research scientists at research institutions and Universities to identify new and additional projects.
- Holding a Ningaloo Research Symposium for all researchers currently involved in research at Ningaloo in July 2007.

2. DATA MANAGEMENT

The database was developed in Microsoft Excel and will be maintained in this format by the Marine Science Program, DEC. It contains detailed information on each project including principle researcher, project title, objectives or expected outcomes, timeframe and contact details of the principle researcher. Abstracts from many of the projects may be found in the Ningaloo Symposium Proceedings (2007). Projects that were included in the 2006 database, but have been completed have been removed from this database and added to the Ningaloo Bibliography maintained by Shannon Armstrong, DEC.

The Marine Science Program will establish and maintain a metadata database to ensure that a record is kept of all research projects with relevant information on the project status, data products, data custodian (or contact) and any publications or other communication outcomes from the project.

2.1. Report

Hard and digital copies of the report will be held at three locations:

1. Marine Science Program (MSP) Library, Department of Environment and Conservation, Science Division, 17 Dick Perry Ave, Technology Park, Kensington, WA. Ph: (08) 93340 228 (email: kelly.waples@dec.wa.gov.au).

2. Exmouth District Office, Department of Environment and Conservation, Payne St. Exmouth, WA. Ph: (08) 99491676 Fax: (08) 99491580

3. Woodvale Library, Science Division, Department of Environment and Conservation, Ocean Reef Rd., Woodvale, WA. Ph: (08) 94055100 Fax: (08) 93061641

2.2. Database

The database will be located as follows:

1. On the DEC MSP server, accessible via the following directory pathway: T:\529-CALMscience\Shared Data\Marine Science Program\Ningaloo databases\NMP Research 2007\NMP Current Research 2007

2.3. Database Maintenance

Maintenance of the database will be the responsibility of DEC's MSP. **It will greatly enhance this database and the research effort at NMP if the DEC could be advised of any new or proposed research projects. To that end, a form has been designed with the necessary information to update the database (Appendix 3).** Any new records should be sent to:

1. Dr Kelly Waples, Marine Science Program, Science Division, 17 Dick Perry Ave, Technology Park, Kensington, 6151: ph 08 9334 0246; email kelly.waples@dec.wa.gov.au

The database will be updated on a six-month basis. During the updating process completed projects will be removed from the database and entered into the 'Bibliography of Marine Research Projects Relevant to Ningaloo Marine Park and Adjacent Waters' (Armstrong, 2006).

3. LIST OF ALL CURRENT MARINE RESEARCH PROJECTS IN THE NINGALOO MARINE PARK

Table 3.1 All Current Research Projects

Projects are listed by Principle Researcher and information is included on title, objectives, research team and current status where this information has been available. Additional details will be included as they are provided to the MSP.

* Management strategy refers to the management strategies relating to research and monitoring activities for *ecological values* only detailed in the Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005-2015. Application to management strategies for social values have yet to be assessed. The reference system used in this table is adopted from the NMP Research and Monitoring Plan which is attached as Appendix 1. Strategy priority is also included (H-KMS – High Key Management Strategy, H- High, M – Medium, L- Low).

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Abel, Nick	Indigenous livelihoods: Land and inshore access and use rights for sustainable multiple use	CSIRO	Benedict Scambary, CSIRO	2007-2010	Investigate a range of inter-related Indigenous livelihood practices and aspirations relating to the NMP and identify a range of values, rules and norms that determine Indigenous use and access to the Ningaloo Reef.	NA	nick.abel@csiro.au	Ningaloo Cluster project 5.5 - subproject of Cluster 5
Armstrong, Shannon	Long term monitoring of NMP: Status of *Drupella* and shallow water benthic reef communities.	DEC	NA	Ongoing	Determine changes to *Drupella* density and percentage cover of coral communities at NMP over time	M8 (H), R18 (H), R19 (H)	shannon.armstrong@dec.wa.gov.au	
Babcock, Russ	Ecosystem impacts of human usage and the effectiveness of zoning for biodiversity	CSIRO, UWA, ECU	Mat Vanderklift, Mick Haywood, Geordie Clapin (CSIRO), Ben Fitzpatrick (UWA), Glen Hyndes (ECU), Bob Black (UWA)	2006-2008	Measure the distribution and abundance of organisms on the reef and assess their variation in the context of both previous and current zoning (size, age, configuration) and habitat to contribute to an assessment of the appropriateness of sanctuary zones in the NMP	R3 (HKMS), R12 (HKMS), M1(HKMS), R11 (HKMS), M5 (HKMS)	russ.babcock@csiro.au	WAMSI project 3.2.2 - contains 3 subprojects

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Babcock, Russ	Effectiveness of sanctuary zones for protecting exploited subtidal fish species	CSIRO, UWA, ECU	Mat Vanderklift, Mick Haywood, Geordie Clapin (CSIRO), Bob Black (UWA), Glen Hyndes (ECU)	2006-2010	Provide an assessment of indirect effects on fish community structure from fishing activities in NMP	R3 (HKMS), R12 (HKMS), M1(HKMS), R11 (HKMS), M5 (HKMS)	russ.babcock@csiro.au	WAMSI project 3.2.2a- subproject of 3.2.2
Babcock, Russ	Assessment of trophic cascade effects	CSIRO, ECU	Mat Vanderklift, Mick Haywood, Geordie Clapin (CSIRO), Glen Hyndes (ECU)	2006-2010	Provide an assessment of indirect effects on benthic community structure from fishing activities in NMP	M4 (H-KMS); M8 (H); M20 (M)	russ.babcock@csiro.au	WAMSI project 3.2.2c- subproject of 3.2.2
Beckley, Lynnath	High resolution mapping of reef utilisation by humans at Ningaloo	Murdoch	Claire Smallwood, Susan Moore, Halina Kobryn, Chris Jones, Jody Nieman, Mandy Lombard (Murdoch)	2006-2010	Determine spatial and temporal distribution of recreational activities along the shore and within the reef lagoon system of NMP Investigate the spatial distribution of recreational use in relation to biodiversity, habitats, physical conditions, park zoning, access roads and tracks and accommodation nodes Describe the demographics, frequency of visitation, choice of destination, socioeconomics, and catches of rec fishers Develop an understanding of historical use patterns at NMP from other potential sources of data on reef utilisation	M1 (H-KMS); M3 (H-KMS); M6 (H); M10 (H)	L.Beckley@murdoch.edu.au (08) 9360 6392	Ningaloo Cluster project 2

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Black, Bob	Effectiveness of sanctuary zones for protecting exploited intertidal invertebrate species	UWA	Russ Babcock (CSIRO)	2006-2011	Provide an assessment of indirect effects on invertebrate community structure from fishing activities in NMP	R7 (H-KMS); M5 (H-KMS)	rbalck@cyllene.uwa.edu.au; 6488 1029	WAMSI project 3.2.2b- subproject of 3.2.2
Burton, Michael	Estimation and integration of socioeconomic values of human use of Ningaloo in the MSE model structure	UWA, ANU	Tom Kompas, Quentin Grafton (ANU), Ben White (UWA), Dr Atakelty Hailu (UWA)	2006-2010	To develop an empirical model to explain choice of recreational sites and use as a basis for economic welfare and policy evaluation		mburton@fnas.uwa.edu.au	Ningaloo Cluster project 4- contains 3 subprojects
Burton, Michael	Survey of recreational fishing choices	UWA	Atakelty Hailu, Ben White, Jananee Raguragavan (UWA), Tom Kompas (ANU)	2006-2010	Understand destination choice for users of the NMP		mburton@fnas.uwa.edu.au	Ningaloo Cluster project 4.1 - subproject of Cluster 4
Burton, Michael	Random utility models for recreational fishing choices	UWA	Atakelty Hailu, Ben White, Jananee Raguragavan (UWA), Tom Kompas (ANU)	2006-2010	Estimate economic values associated with recreational fishing in the NMP		mburton@fnas.uwa.edu.au	Ningaloo Cluster project 4.2 - subproject of Cluster 4
Burton, Michael	Random utility models for other non-recreational tourist activity choices	UWA	Atakelty Hailu, Ben White, Jananee Raguragavan (UWA), Tom Kompas (ANU)	2006-2010	Estimate economic values associated with other recreational activities in the NMP		mburton@fnas.uwa.edu.au	Ningaloo Cluster project 4.3 - subproject of Cluster4
Caley, Julian	Sloane Census of Marine Life	AIMS	Not Available	2007-2008	Ningaloo Reef will serve as one reference site in the global project censusing marine life.		j.caley@aims.gov.au	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Catlin, James	Sustainability of the whale shark tourism industry at Ningaloo	Curtin	Not Available	2006-2009	Not Available	M12 (H); M20 (M)	james.catlin@gmail.com	
Collins, Lindsay	Geological history of Cape Range and Ningaloo Marine Park. (Geological evolution of Ningaloo Reef. Evolution and climate history of the Limestone of the Cape Range)	Curtin	Not Available	2007	Collection of rock samples for study into geological evolution, marine processed, reef growth history and land management of the Cape Range region	R51 (L)	L.Collins@curtin.edu.au (08) 9266 7968	Ongoing
Collins, Lindsay	Characterisation of geomorphology, growth history and surface sediments	Curtin	Emily Twiggs (Curtin)	2006-2009	Characterise the coastal and seabed geomorphology of the reef system, including the deeper reserve areas offshore of the fringing reef Characterise the surficial sediments of the shallow (lagoonal) waters Characterise the morphology and growth history of the reef system and identify growth characteristics relevant to maintenance of marine biodiversity and climate change impacts	R13 (H), R36 (H), R41 (M), R51 (L)	l.collins@curtin.edu.au; 9266 7968	WAMSI project 3.4; PhD project for Emily Twiggs
Dambacher, Jeff	Qualitative modelling for sustainable tourism development	CSIRO	NA	2007-2011	Develop alternative constructs of socio-economic and ecological system modelling based on patterns, processes and responses determined from Cluster and WAMSI projects; explore the consequences of model structure and system dynamics; and facilitate stakeholder involvement in the process		Jeffrey.Dambacher@csiro.au (03) 6232 5096	Ningaloo Cluster project 5.2 - subproject of Cluster 5

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Davis, J	Coastal stewardship in WA	Murdoch	Not Available	Not Avail	Not Available		J.K.Davis@murdoch.edu.au	
De la Mare, Bill	Management Strategy Evaluation (MSE) for the Ningaloo Region	CSIRO	David McDonald, Jeff Dambacher, Beth Fulton , Nick Abel, Jeff Syme, Keith Sainsbury (CSIRO)	2007-2011	Develop and provide the integrated modelling and analysis for Multiple use MSE of the Ningaloo region using outputs of the all Cluster and WAMSI projects.	R12 (H-KMS), M6 (H), M13 (H)	david.mcdonald@csiro.au (03) 6232 5482	Ningaloo Cluster project 5 - contains 5 subprojects
Deery, Marg	Resident survey of social impacts of tourism	VU	Liz Fredline (Griffith), David Wood, Tod Jones (Curtin)	2007-2008	Compile information on residential views of the impacts of tourism for inclusion into the Ningaloo coast dynamic model.		t.jones@curtin.edu.au	Ningaloo Cluster Project 3.3, subproject of Cluster 3
Dwyer, Larry	Assessment of economic values of tourism	UNSW	Ray spur (UNSW), David Wood, Tod Jones (Curtin)	2007-2008	Provide an assessment of the economic value of tourism in the Ningaloo Coast area to the socio-economic tourism model		t.jones@curtin.edu.au	Ningaloo Cluster Project 3.4, subproject of Cluster 3
Feng, Ming	Impact of climate variability and climate change on coastal marine ecosystem	CSIRO	Not Available	Not Avail	Quantify the climate variability in the Leeuwin Current physical forcings on the coastal ecosystem	R17 (H)	ming.feng@csiro.au (08) 9333 6512	WAMSI Node 2 project
Fitzpatrick, Ben	Fish biodiversity associated with habitat types in sanctuary and adjacent zones in deeper waters	AIMS, UWA	Andrew Heyward, (AIMS), Euan Harvey, (UWA)	2006-2009	Characterise the fish biodiversity associated with habitat types and dominant macro benthic communities in sanctuary zones and nearby comparison sites in waters between 20-100m depth	R6 (H-KMS), R26 (H)	a.heyward@aims.gov.au	WAMSI project 3.1.1b- subproject of 3.1.1; PhD student

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Fowles, Brooke	A history of fish and fishing in Ningaloo	UWA, DEC	A. Gaynor (UWA)	2007	Analyse the historical prevalence of specific finfish within the bioregion with reference to oral history interviews and other historical sources, and evaluate the utility of this methodology.		agaynor@arts.uwa.edu.au (08) 6488 2137	Honours Student
Fromont, Jane	Species inventory database for Ningaloo Deep waters	WAM AIMS	Sue Morrison, M. Titelius, C. Whisson, M. Salotti (WAM)	2007-2009	Collect voucher specimens to form the foundation of a species inventory database for Ningaloo deeper waters.	R4 (H-KMS), R7 (H-KMS), R16 (H), R21 (H)	jane.fromont@museum.wa.gov.au (08) 92123 746	WAMSI project 3.1.1d- subproject of 3.1.1
Fromont, Jane	The significance of historical collections: Ningaloo	WA museum	Not Available	2006-ongoing	Data base the common marine invertebrates from Ningaloo as indicated from historical collections dating back to the 1960s		jane.fromont@museum.wa.gov.au (08) 92123 745	
Fulton, Beth	Integrated software for multiple use management strategy evaluation	CSIRO	Fabio Boschetti, Mark Gray (CSIRO),	2007-2011	Simulate using a variety of factors including biophysical, social, assessment, monitoring and management policy for multiple use management strategy evaluation		Beth.Fulton@csiro.au	Ningaloo Cluster project 5.3 - subproject of Cluster 5
Gazzani, Flavio	Economic valuation of biodiversity conservation. Citizen's non-use value for Ningaloo Reef	Murdoch	NA	Not Avail	Estimate the benefits of non-use values of the NMP and how choices may be related to socio-economic characteristics using Choice Modelling.		f.gazzani@murdoch.edu.au	
Harcourt, R	Australian Telemetry and Acoustic Monitoring System	IMOS	Not Available	Not Avail	Initiate both a fine and broad scale acoustic curtain at several sites along the NMP to enhance research projects identifying fine and large scale movement of particles and species		rharcour@gse.mq.edu.au	ATAAMS project

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Heyward, Andrew	Deepwater Communities at Ningaloo Reef	AIMS	Jamie Colqhoun (AIMS), Euan Harvey, Ben Fitzpatrick (UWA), Rob McCauley, Emily Twiggs (Curtin), Jane Fromont (WAM)	2006-2009	Assess the biodiversity value of the deeper waters seawards of the reef crest in the NMP with a focus on representativeness of sanctuary zones.	R16(H), R4 (HKMS), R21 (H), R7 (HKMS), R10 (HKMS), R6 (HKMS)	a.heyward@aims.gov.au	WAMSI project 3.1.1 - contains 4 subprojects
Heyward, Andrew	Deep water habitat types	AIMS	Jamie Colquhoun, P. Speare, Fiona McAllister (AIMS)	2006-2010	Characerise the habitat types and dominant macro benthic communities in sanctuary zones and nearby comparison sites in waters between 20-100m depth	R4 , R16, R21, R10	a.heyward@aims.gov.au	WAMSI project 3.1.1a- subproject of 3.1.1
Heyward, Andrew	Methods for monitoring the health of benthic communities	AIMS	James Gilmour (coral), Ben Fitzgibbon, Angus Thompson (fish) (AIMS)	2006-2010	To design parameters for a long term monitoring program for coral and fish communities in NMP addressing recruitment, and spatial and temporal replication

Provide baseline data for this program | R10 (HKMS), R1 (HKMS), R2 (HKMS), R5 (HKMS), M5(HKMS), R17 (H) | a.heyward@aims.gov.au | WAMSI project 3.1.2 |
Heyward, Andrew	Stock assessment of target invertebrates	AIMS, UWA	A. Thompson, I. Miller (AIMS), E Harvey (UWA)	2008-2009	Assess status of target species; characterise habitats associated with abundance and compare abundance in relation to human use	R6 (HKMS), R7 (HKMS), R10 (HKMS)	a.heyward@aims.gov.au	WAMSI project 3.1.3
Heyward, Andrew	Coring of Porhytes to determine impacts of climate change	AIMS	Not Available	Not Avail	Not Available	R17 (H)	a.heyward@aims.gov.au	
Heyward, Andrew	Reef coral population dynamics and annual recruitment processes of spawning coral	AIMS	Not Available	Not Avail	Not Available	R1 (H-KMS)	a.heyward@aims.gov.au	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Heyward, Andrew	Coral reef disease - White Syndrome	AIMS	Not Available	Not Avail	Detect whether Ningaloo has been infected with white syndrome		a.heyward@aims.gov.au	
Hodgson, Amanda	Distribution and abundance of dugongs in NMP and Exmouth Gulf	James Cook University	Not Available	Ongoing	Establish the abundance of dugong in NMP in relation to Shark Bay and Exmouth Gulf	R47 (M)	amanda.hodgson@jcu.edu.au; 07 4781 6941	aerial surveys every 5 years between May and June, total budget to be confirmed. Surveys cojnductged May 07.
Holliday, Dave	Cross-shelf transport induced by meso-scale eddies of the Leeuwin Current: implications for the larvae of neritic biota	UWA	Not Available	Not Avail	Investigate the bio-physical dynamics of meso-scale eddies of the Leeuwin Current and implications for recruitment variability		D.Holliday@murdoch.edu.au (08) 9239 8807	WAMSI Node 2 project
Hughes, Michael	Environmental load survey of accommodation providers	Curtin	Tod Jones (Curtin), Karin Schianetz UQ)	2007-2008	Develop a dynamic model of Ningaloo incorporating social, economic and environmental management assessment of tourism along the Ningaloo coast		t.jones@curtin.edu.au	Ningaloo Cluster project 3.2, subproject of Cluster 3
Humphries, Stuart	Suspension feeders and energy flow through reefs	UWA	Anya Waite (UWA)	2005-2009	Not Available	R4 (H-KMS	s.humphries@sheffield.ac.uk +44 (0)114 222 0032	
Jenner, Curt	Geographical and temporal boundaries for whales of Ningaloo	Centre for Whale Research	Micheline Jenner	Ongoing	Identify the movement and distribution patterns of humpback whales relative to the NMP.	R46 (M)	curtjenner@telstra.com; information@cwr.org.au; 0418 912 669	
Jones, Tod	Ningaloo destination mo9del for scenario evaluation and collaborative planning	Curtin	Karen Schianetz (UQ)	2007-2009	Develop a dynamic model of Ningaloo incorporating social, economic and environmental management assessment of tourism along the Ningaloo coast		t.jones@curtin.edu.au	Ningaloo Cluster project 3.5, subproject of Cluster 3

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Keesing, John	An assessment of likely dispersal patterns for marine organisms based on hydrodynamic and population genetic models	CSIRO	Not Available	2006-2010	The distribution of genetic structure throughout WA range of two (or more) widespread urchin species with differing reproductive and larval biology and contrasting dispersal potential will be characterised using DNA sequence information		john.keesing@csiro.au (08) 9222 8887	
Kingham, A	Sustainability of the wilderness experience : a case study in environmental stewardship	Curtin	Not Available	Not Avail	Not Available	R33 (H)	andrew@ComptonVale.com 0439 575 892	r.jones@curtin.edu.au
Kobryn, Halina	Hyperspectral mapping - Habitats	Murdoch	Nicole Pinnel (Murdoch)	2006-2008	Develop a high resolution characterisation of the reef and shallow water habitats of the NMP that will provide the basis for future multiple use management and planning	R20 (H), R43 (M)	h.kobryn@murdoch.edu.au (08) 9360 2411 keulen@murdoch.edu.au (08) 9360 2369	Ningaloo Cluster project 1.2 - subproject of Cluster 1
Kuchling, Gerald	Temperature profiles of sea turtle nesting beaches in Western Australia	UWA, DEC	Keith Morris	2004-2007	Provide an overview of temperature variation at sea turtle nesting beaches and allow rough estimates of sex ratio variations according to published male and female producing temperatures for the different species		kuchling@cyllene.uwa.edu.au (08) 9380 2243	
Long, Suzanne	Bills Bay Coral Recovery Research and Monitoring Project	DEC	NA	Ongoing	Determine the recovery of corals in Bills Bay after the 1989 anoxic coral spawning event	M7 (H)	Suzanne.long@dec.wa.gov.au	
Lovelock, Cath	Nutrient limitation and impact of nutrient enrichment on arid zone mangroves	UQ	Ilka Feller, G Skilleter, S Joyce (UQ)	Ongoing	Understand the degree of connectivity between the terrestrial environment and estuaries in the arid tropics of Australia.	R23 (H)	c.lovelock@uq.eud.au 08 9222 8887	ARC project LP0561498. Collaborators Straits Resources Ltd and MG Kailis Group

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Lynch, Merv	Hyperspectral mapping - Bathymetry	Curtin	Wojciech Klonowski (Curtin), Peter Feans (murdoch), Mark Grey (Murdoch)m Janje (?) (Murdoch PhD)	2006-2009	Use the hyperspectral data to create a bathymetry data set and broad scale classification of the lagoon habitats over the extent of the NMP

Develop a radiation transfer model and optimisation code that can be used by researchers on a number of different systems to reprocess atmospherically corrected reflectance data. | | M.Lynch@curtin.edu.au (08) 9266 7540 | Ningaloo Cluster project 1.1 - subproject of Cluster 1 |
| Marriott, Ross | Stock assessment of spangled emperor | DoF | Not Available | Not Avail | To assess spangled emperor stock in NMP for integrated fisheries management of the Gascoyne bioregion. | R6 (H-KMS) | ross.marriott@fish.wa.gov.au | from Sci licence CE001445 Aug 06 |
| McCartney, Abbie | The policy relevance of Choice Modelling: an application to Ningaloo Marine Park | UWA | Michael Burton (UWA) | 2006-2009 | Investigate the suitability of Choice Modelling as a tool for valuing marine parks and coral reefs using NMP as a case study

Investigate the differences between traditional and non-market valuation payment vehicles and tax reallocation using CM for an environmental good

Contribute towards determining the policy relevance of CM | | mccara01@student.uwa.edu.au | Joint project WAMSI (3.9c) and WFO Ningaloo Cluster (4.4) |
| McCauley, Rob | High resolution data on cross shelf bathymetry and sediment facies | Curtin, AIMS | Rob McCauley, Emily Twigg (Curtin) | 2007-2009 | Improve understanding of the biophysical domain via cross shelf bathymetry and distribution of sediment facies | R13 (H), R41 (M) | R.McCauley@cmst.curtin.edu.au (08) 9266 7460 | WAMSI project 3.1.1c- subproject of 3.1.1 |

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
McCulloch, Malcolm	CO2 Ocean Acidification and the Future of Coral Reefs	ANU	Not Available	2007-2010	Provide an understanding of how ocean acidity is affecting the marine environment and the role of coral reefs in buffering the oceans capacity to recover using real-time measurements of acidity and calcification and long term records from coral skeletons		Malcolm.McCulloch@anu.edu.au (02) 6125 9969	
McDonald, David	Linkage and socioeconomic integration for NMP	CSIRO	Not Available	2007-2011	Integrate the WAMSI MSE project with the Cluster		david.mcdonald@csiro.au (03) 6232 5482	Ningaloo Cluster project 5.1 - subproject of Cluster 5
McDonald, David	Management Strategy Evaluation	CSIRO	Richard Little (CSIRO)	2007-2011	Assess the impact of existing zonal management strategies on key target fish species and biodiversity using background data and knowledge currently held or being gathered	R12 (H-KMS), M6 (H), M13 (H)	david.mcdonald@csiro.au (03) 6232 5482	WAMSI project 3.2.3
McGregor, Frazer	Trophic ecology of Manta Rays within lagoonal systems of the NMP	Coral Bay Progress Assoc., DEC, NWRA, Murdoch University	NA	2007-2009	Investigate the tropic links between manta rays and the Ningaloo reef using mark recapture studies and assessing primary production.	R29 (H); R8 (H-KMS); R28 (H)	frazer_mcgregor@yahoo.com.au	
Meekan, Mark	Whale sharks, migration and ecology Movements and behaviour of Whale Sharks with use of acoustic, satellite, PAT, crittercam and genetic tagging.	Hubbs Seaworld, CSIRO, DEC	Jeff Polovina (NOAA), John Stevens (CSIRO), Steve Wilson (Hubbs Sea world)	2006-2009	Determine movement and behaviour of Whale Sharks - part of the Whale Shark Management Program	R44 (M), R45 (M), M20 (M)	m.meekan@aims.gov.au (08) 8920 9240, 0429 101 812; jeffrey.polovina@noaa.gov	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Meekan, Mark	Local and regional migratory patterns of whale sharks	CSIRO	John Stevens, Mark Horsham, (CSIRO)	2007-2008	Characterise whale shark abundance in and use of the NMP in support of management strategies for the whale shark ecotourism industry.	R8 (H-KMS), R9 (H-KMS), R44 (M), R45 (M)	m.meekan@aims.gov.au (08) 89209240, 0429 101 812,	WAMSI project 3.1.4
Moore, P	Using the past to understand the future: the effects of climate change on regional diversity patterns of coralline algae	UQ	Not Available	Not Avail	Investigate the regional effects of climatic warming on the community composition and biogeographic range of crutose coralline algae along a 12 degree latitudinal gradient of Western Australia's coral reefs	R17 (H)	pippa.moore@uq.edu.au	
Neiman, Jody	Diurnal variability in beach use patterns at Bundegi, Turquoise Bay and Coral Bay, Ningaloo Marine Park	Murdoch, DEC	Lynnath Beckley (Murdoch)	2007	Determine the diurnal pattern of human usage at Bundegi, Turquoise Bay and the main beach at Coral Bay by addressing the diurnal variation in beach use and can an understanding of beach use patterns facilitate an improved approach to beach management		j.neiman@murdoch.edu.au	Funding application pending decision
Norman, Brad	Whalesharks	Ecooceans	Not Available	Ongoing	Collect baseline data on whalesharks at NMP by photo id, whale shark sex and size, deployment of data logging tags and collection of plankton samples to determine whale shark prey items	R44 (M), R45 (M), M20 (M)	brad@whaleshark.org	
Northcote, J	Socio-economic impacts of sanctuary zone changes in NMP: a preliminary investigation of effects on visitation patterns and human usage	ECU	Jim Macbeth, Sue Moore, Colin Ingram	2006-2007	Assess potential socio-economic impacts from the expansion of sanctuary zones in NMP on visitors and residents		j.northcote@ecu.edu.au	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Pandolfi, John	Ecological effects of climate change on regional diversity patterns of WA coral reefs	UQ	Not Available	Not Avail	Not Available	R17 (H)	j.pandolfi@uq.edu.au; 07 3365 3050	
Pattiaratchi, Chari	SERPENT: Scientific and Environmental ROV Partnership using Existing Industrial Technology	UOS, UWA, UOW, UTS, Woodside, Santos, Chevron	Not Available	Not Avail	International project in collaboration with oil and gas industry to undertake deep-sea research using ROV technology		chari.pattiaratchi@uwa.edu.au (08) 6488 3179	ARC linkage grant, North West Shelf
Pattiaratchi, Chari	Characterisation and modelling of oceanographic processes in Ningaloo Reef and adjacent waters	UWA	Ryan Lowe, Greg Ivey, Anya Waite, Alex Wyatt (UWA) Graham Symonds (CSIRO)	2007-2010	Develop the capacity to numerically simulate waves, currents, sediment transport and particle dispersion in a shallow complex reef environment over time and space scales	R14 (H), R15 (H), R17 (H), R45 (M), OSI 3.1	chari.pattiaratchi@uwa.edu.au (08) 6488 3179	WAMSI project 3.5
Pattiaratchi, Charitha	WAIMOS - West Australian Integrated Marine Observation System	UWA	Not Available	Not Avail	The WA component of IMOS, real time monitoring concentrated along the Jurien-Cape Peron coastal stretch and 3 long term reference sites; Dampier, Rottnest and Esperence.		chari.pattiaratchi@uwa.edu.au (08) 6488 3179	
Penrose, Hellen	Trophic connectivity via nekton in an arid zone estuarine landscape	UWA, UQ	Not Available	2005-2008	To determine:1) the relative importance of mangroves v cyanobacterial mats in supporting nekton in an arid zone estuary; 2) whether trophic connectivity via nekton is dependent on spatial arrangement; and 3) whether tidal movements of the giant shovelnose ray (*Rhinobatos typus*) represent an important biotic vector of energy transfer.	R23 (H)	s4091865@student.uq.edu.au	Study focuses on eastern side of Exmouth Gulf

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Prince, Bob	Turtle tagging program	DEC	Not Available	Ongoing	Long term monitoring program of marine turtle nesting populations in the NMP	R30 (H)	bob.prince@dec.wa.gov.au	
Rodger, K	Role of science in managing the impacts of wildlife tourism	Murdoch, STCRC	Not Available	Not Avail	Not Available		K.Rodger@murdoch.edu.au (08) 9360 2902	
Simpson, Chris	NW Marine Research Inventory	DEC	Tim Skewes, Tom Taranto, Mat Vanderklfit (CSIRO), Kelly Waples (DEC),	2007-2008	Develop a meta database of marine and coastal research completed, current or proposed in WA (State and Commonwealth waters) form Kalbarri to the NT border in order to understand what scientific information currently exists for this region to facilitate a strategic and collaborative approach towards further marine research in Northern WA		chris.simpson@dec.wa.gov.au	WAMSI project 3.8
Sleeman, J	Modelling whale shark distribution	Charles Darwin uni	Not Available	2004-2007	Not Available	R44 (M), R45 (M), M20 (M)	jai.sleeman@cdu.edu.au (08) 8946 7207	
Stevens, John	Diversity, abundance and habitat utilisation of sharks and rays	CSIRO, DoF	William White (CSIRO), Justin Chidlow (DoF)	2007-2008	Characterise shark and ray diversity and abundance in the reserves and support development of management targets for them.	R8(HKMS), R28 (H)	john.d.stevens@csiro.au; 03 6232 5353	WAMSI project 3.2.1
Stewart, Brent	Range and habitats of whale sharks in the Eastern Indian Ocean	Hubbs Seaworld, CSIRO, AIMS, DEC, NOAA	Steven Wilson (Hubbs), Jeffrey Polovina (NOAA), Mark Meekan (AIMS), John D Stevens (CSIRO)	2005-2008	Document the seasonal movements and habitat use of whale sharks at NMPO between March and June using satellite tags	R44 (M), R45 (M), M20 (M)	bstewart@hswri.org	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Symes, Jeff	NREP Client outreach	CSIRO	Peta Dzidic, CSIRO	2007-2011	Integrate the WAMSI and Cluster research and ensure implementation of outcomes through relevant stakeholders		scott.condie@csiro.au	Ningaloo Cluster project 5.4 - subproject of Cluster 5
Trocini, S.	Conservation of the endangered loggerhead turtle (*Caretta caretta*): health assessment and hatching success of Western Australian populations	Murdoch, DEC	Not Available	Not	Identify & quantify various biotic & abiotic risk factors that reduce hatching success of loggerhead turtles	R30 (H), R9 (H-KMS)	S.Trocini@murdoch.edu.au	approx 3 year project, DEC providing in-kind support
Underwood, Jim	Larval dispersal, gene flow and disturbance in two coral species in northern WA	UWA, AIMS	Madelain VanOppen (AIMS), James Gilmour (AIMS), Luke Smith (AIMS), Mike Johnson (UWA)	2004-2007	Investigate fundamental processes that influence the dynamics of survival, regeneration and evolution of species in the marine environment, the spatial scale and pattern of demographic connection among populations at NMP	R1 (H-KMS)	underj01@student.uwa.edu.au (08) 6488 1483	research finished, handing in thesis November 07
Usher, Kayley	Investigating the importance, diversity and host specificity of photosynthetic symbionts in marine sponges from tropical and temperate regions	DEC, UWA	Not Available	2008-2010	Determine; the percentage of photosynthetic sponges on temperate and tropical reefs, diversity of photosynthetic symbionts of sponges, biogeography of symbiont classes, the abundance of symbiont classes and range of host sponges.		kusher@cyllene.uwa.edu.au	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
van Keulen, Mike	Habitats and Biodiversity of Ningaloo Reef lagoon	Murdoch, Curtin, UQ	Keith Sainsbury (CSIRO), Halina Kobryn (Murdoch)	2006-2010	Provide comprehensive information on habitats and biodiversity in the NMP Qualitatively and quantitatively describe the biodiversity values of t selected areas of the reef in relationship to the bio-physical environment, patterns of reef use and access form land, linking these with physical and biological surrogates to enable specific biodiversity values to be applied across the NMP Identify hot spots and develop an understanding of the environmental and habitat factors that explain the distribution of these hotspots	R20 (H), R43 (M)	keulen@murdoch.edu.au (08) 9360 2369	Ningaloo Cluster project 1 - contains 3 subprojects
van Keulen, Mike	Biodiversity - soft corals, macroalgae, macro invertebrates	Murdoch	Neil Loneragan (Murdoch, Greg Skilleter (UQ), PhD students	2006-2010	Provide comprehensive information on habitats and biodiversity with a focus on sponges, soft coral and macroalgae	R4 (H-KMS), R20 (H), R21 (H), R22 (H)	keulen@murdoch.edu.au (08) 9360 2369	Ningaloo Cluster project 1.3 - subproject of Cluster 1
van Keulen, Mike	Seagrasses and macroalgae of Ningaloo	Murdoch	Not Available	Ongoing	Not Available	R22 (H)	keulen@murdoch.edu.au (08) 9360 2369	Ongoing, potential PhD project
Waite, Anya	The biological oceanography of Ningaloo Reef: coastal plankton as a food source for the reef. Assessing the vulnerability of Ningaloo Marine Park to pollution	UWA	Not Available	Not Avail	Not Available		waite@cwr.uwa.edu.au (08) 6488 3082	

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Warren, Kristin	A study of hatching success and sea turtle health in Western Australia	Murdoch	Not Available	2006-2009	Determine disease prevalence, health risk factors, causes of mortality, and factors influencing hatching success in three sea turtle species.	R30 (H)	k.warren@murdoch.edu.au 9360 2647	
Webb, J	Impacts of stress on coral reproduction	Murdoch	Not Available	2007	Quantify metabolic consequences of reproduction in zooxanthellate scleractinian corals at Ningaloo Reef and assess their vulnerability to stress during reproductive period		j.p.webb@murdoch.edu.au; 9360 6685	
Williams, Alan	Southern Surveyor Voyage	CSIRO	Felicity McEnulty	Not Avail	Not Available		Alan.williams@csiro.au	
Wood, David	Social and economic assessment of tourism along the Ningaloo Coast: a dynamic modelling approach (Socio-economics of tourism)	Curtin, UNSW, STCRC, ECU	Michael Hughes , Tod Jones (Curtin), Jeremy Northcote, Pascale Scherrer, Pierre Horwitz (ECU), Karin Schianetz (UQ), Marg Dreery (VU), Liz Fredine (Griffith), Larry Dwyer, Ray Spurr (UNSW)	2006-2009	Develop a dynamic model of Ningaloo incorporating social, economic and environmental management assessment of tourism along the Ningaloo coast Assess the social-economic implications of tourism to the Ningaloo coast Use the model to investigate the impacts of different tourism and development scenarios on the economy, communities and environments of Ningaloo and its surrounding regions		d.wood@curtin.edu.au; 9266 7280; 0412 203 630	Ningaloo Cluster project 3 - contains 5 subprojects
Wood, David	Continuation of long term survey of visitation	Curtin	Tod Jones (Curtin)	2007-2011	Not Available		d.wood@curtin.edu.au	Ningaloo Cluster project 3.1 - subproject of Cluster 3

Principle Researcher	Title	Institution	Key Researchers	Status	Objectives	Mgt Strategy*	Contact details	Comments
Wyatt, Alex	Trophic ecology of coral reefs: the role of oceanographic-to-organism scale processes in trophodynamics and benthic-pelagic coupling	UWA	NA	Not Avail	Link benthic ecology and biological oceanography to elucidate the extent and mechanisms by which coral reefs are nutritionally linked to the surrounding pelagic environment and susceptible to its alteration		awyatt@graduate.uwa.edu.au; 6488 1686	

Table 3.2 WAMSI Research Projects

This is a list of all research projects being undertaken within Node 3 of WAMSI as part of the government funded Ningaloo Research Program. Each of these projects has a full entry in the main database (and Table 3.1 above) under the Principle Investigator.

Node Leader: Dr Chris Simpson, DEC

Project No.	Project Title	Project Leader	Subproject
3.1	**Biodiversity assessment and development of cost-effective monitoring protocols.**	**Andrew Heyward AIMS**	**3.1.1** Deepwater communities at Ningaloo Reef. 3.1.1a Deep water habitat types *Andrew Heyward, (AIMS)* 3.1.1b Fish biodiversity associated with habitat types in sanctuary and adjacent zones *Ben Fitzpatrick, (UWA)* 3.1.1c High resolution data on cross shelf bathymetry and sediment facies *Rob McCauley, Emily Twiggs, (Curtin)* 3.1.1d Species inventory database for Ningaloo deep waters *Jane Fromont, (WAM)* **3.1.2** Methods of monitoring the health of benthic communities at Ningaloo Reef *Andrew Heyward (AIMS)* **3.1.3** Stock assessment of target invertebrates at Ningaloo reef *Andrew Heyward (AIMS), Euan Harvey (UWA)* **3.1.4** Local and regional migratory patterns of whale sharks at Ningaloo Reef. *Mark Meekan (AIMS)* **3.1.5** Ningaloo Research Program start-up project for habitat and biodiversity surveys in the deep waters of the Ningaloo Marine Park **3.1.6** Ningaloo Research Program start-up project for physical oceanography of the Ningaloo Marine Park. *Richard Brinkman (AIMS)*

Project No.	Project Title	Project Leader	Subproject
3.2	**Biodiversity assessment, ecosystem impacts of human usage and management strategy evaluation.**	**Russ Babcock CSIRO**	**3.2.1** Diversity, abundance and habitat utilisation of sharks and rays. *John Stevens (CSIRO)* **3.2.2** Ecosystem impacts of human usage and the effectiveness of zoning for biodiversity conservation. *Russ Babcock (CSIRO)* 3.2.2a Effectiveness of sanctuary zones for protecting exploited subtidal fish species *Russ Babcock (CSIRO), Glenn Hyndes (ECU)* 3.2.2b Effectiveness of sanctuary zones for protecting exploited intertidal invertebrate species *Bob Black (UWA)* 3.2.2c Assessment of trophic cascade effects *Glenn Hyndes (ECU)* **3.2.3** Management strategy evaluation *David McDonald (CSIRO)* **3.2.4** Ningaloo Research Program start-up project for impacts of human usage, oceanography and management strategy evaluation.
3.3	**Characterisation of water and sediment quality.**	**Assoc. Prof Eric Paling Murdoch**	
3.4	**Characterisation of geomorphology and surficial sediments.**	**Prof Lindsay Collins Curtin**	
3.5	**Characterisation and modelling of oceanographic processes.**	**Prof Charitha Pattiaratchi UWA**	3.5a Assessment of the dominant hydrodynamic processes in the reef lagoon system *Graham Symonds (CSIRO)* 3.5b Numerical simulation fo waves, currents, sediment transport and particle dispersion in a shallow complex reef environment *Ryan Lowe UWA)* 3.5c Assessment of the near4-reef oceanic processes on organism –scale nutrient dynamics *Anya Waite (UWA)*

Project No.	Project Title	Project Leader	Subproject
3.8	**Northwest Marine Research Inventory**	**Chris Simpson - DEC**	Project Team – *Tim Skewes, (CSIRO)*
3.9	**Post-graduate seed funding program**	**Chris Simpson - DEC**	**3.9.1** Deepwater communities at NMP and ecosystem impacts of human usage and the effectiveness of zoning for biodiversity conservation *Ben Fitzpatrick, UWA* **3.9.2** Characterisation of geomorphology and surficial sediments *Emily Twiggs, Curtin* **3.9.3** The policy relevance of Choice Modelling: an application to Ningaloo Marine Park *Abbie McCartney , UWA* **3.9.4** Quantifying impacts of the Leeuwin current on the ecology and biochemistry of the Ningaloo Reef *Cecile Rouseaux*
3.10	**Assessment of the groundwater system and subterranean aquatic fauna of the NMP and adjacent areas**	**Lindsay Collins-Curtin.**	
3.11	**Assessment of the effectiveness of large marine fauna monitoring programs**	**Chris Simpson - DEC**	

Table 3.3 Wealth from Oceans Flagship – Ningaloo Cluster Projects

This is a list of the research projects being undertaken within the CSIRO Wealth from Oceans Ningaloo Cluster. Fuller details are provided on individual projects and/or subprojects in Table 3.1 above under the Principle investigator/Project leader

Ningaloo Cluster leader: Prof Neil Loneragan, Murdoch
WFO Flagship leader: Bill De la Mare, CSIRO

Project No.	Project Title	Project Leader	Subproject
1	**Habitats and Biodiversity of Ningaloo Reef lagoon**	Mike Van Keulen, Murdoch	1.1 Hyperspectral mapping- Bathymetry *Merv Lynch, Curtin* 1.2 Hyperspectrral Mapping – Habitats *Halina Kobryn, Murdoch* 1.3 Biodiversity – soft corals, macroalgae and macro invertebrates *Mike Van Keulen, Murdoch*
2	**High resolution mapping of reef utilisation by humans at Ningaloo**	Assoc. Prof. Lynnath Beckley, Murdoch	
3	**Social and economic assessment of tourism along the Ningaloo Coast: a dynamic modelling approach**	Prof. David Wood, Curtin	3.1 Continuation of long term survey of visitation (Jan 09) *David Wood, Tod Jones, Curtin* 3.2 Environmental load survey of accommodation providers (Jul 08) *Michael Hughes, Tod Jones, Curtin, Karin Schianetz, UQ* 3.3 Resident survey of social impacts of tourism (Jul 08) *Marg Deery, VU, Liz Fredline, Griffith, David Wood, Tod Jones, Curtin* 3.4 Assessment of economic values of tourism (Jul 08) *Larry Dwyer, Ray Spurr, UNSW, David Wood, Tod Jones, Curtin* 3.5 Ningaloo Destination Model for scenario evaluation and collaborative planning (Jul 09) *Tod Jones, Curtin, Karen Schianetz, UQ*

Project No.	Project Title	Project Leader	Subproject
4	**Estimation and integration of socioeconomic values of human use of Ningaloo in the MSE model structure**	Assoc Prof. Michael Burton (UWA) / Dr Atakelty Hailu, UWA	4.1 Survey of recreational fishing choices *Michael Burton* 4.2 Random utility models for recreational fishing choices *Michael Burton* 4.3 Random utility models for other non-recreational tourist activity choices *Michael Burton*
5	**Management Strategy Evaluation for the Ningaloo Region**	Bill DelaMare, CSIRO	5.1 Linkage and socioeconomic integration for NMP *David McDonald, CSIRO* 5.2 Qualitative modelling for sustainable tourism development *Jeff Dumbacher, CSIRO* 5.3 Integrated software for multiple use management strategy evaluation *Beth Fulton, CSIRO* 5.4 NREP Client Outreach *Jeff Symes, CLW* 5.5 Land and inshore access and use rights for sustainable multiple use *Nick Abel, CSIRO*

Table 3.4 Regional DEC research, coordinated by the Exmouth District Office, relevant to the Ningaloo Marine Park, including Marine Community Monitoring Programs (MCMP)
Management strategy refers to strategies identified in the Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005-2015.

Title	DEC contact	Institution	Objectives	Management strategy
Community manta ray monitoring and education	Roland Mau	Coral Bay Progress Assoc. DEC, NWRA, Murdoch University	Develop a standard methodology for long-term monitoring of the manta ray tourism industry	Undertake research on the general ecology of manta rays with the aim to determine potential impacts of human interaction on manta ray populations (High) Undertake community education programs, compliance monitoring and liaison with commercial operators to ensure interaction activities do not significantly impact on manta rays (M)
Coral Bay Boating Facility Coral Community Impact Monitoring	Roland Mau	DEC	To establish community monitoring sites relevant to the new Boating facility in Coral Bay	Ensure that proponents of development proposals or commercial activities with the potential to impact on the reserves' values conduct appropriate compliance monitoring programs (High)
Coral Bay Vessel Usage Monitoring	Kim Onton	NSDO (DPI)	To determine vessel use patterns at Coral Bay for the Coral Bay Boating Strategy	Implement a Mooring Plan, including the establishment and maintenance of public and private moorings, for the reserves in line with the MPRA/CALM Mooring Policy (High)
DEC Patrol Logs - Compliance Monitoring	Brad Daw	DEC, DoF	To determine SZ compliance levels and areas of concern	Develop and implement a surveillance and enforcement program, in collaboration with DoF, to ensure an adequate level of compliance with Park regulations with a particular focus on sanctuary zone restrictions (H-KMS)

Title	DEC contact	Institution	Objectives	Management strategy
Exmouth Patrol Logs - Human Usage Monitoring	Michelle Hughes		To determine use patterns at NMP and monitor changes over time	Within the reserves; Assess the nature, level and potential environmental impacts of commercial tourism operations (H). Maintain a database of the nature, spatial and temporal patterns and potential environmental impacts of commercial tourism operations (H). Continue to undertake research and monitoring of the ecological effects of recreational fishing and review management controls as appropriate (H-KMS).
MCMP: Bleaching and coral predators	Brooke Halkyard	DEC	To evaluate the health of corals by monitoring the: I. effects of global warming on coral reefs (bleaching); 2.impact of coral predators on coral health	Encourage community and local industry involvement in reserve management (including education and monitoring activities) monitoring programs (H-KMS)
MCMP: Coral damage from snorkelling	Brooke Halkyard	DEC	To evaluate the health of corals by monitoring the damage inflicted by visitors to high use sites	Assess the nature, level and potential impacts of human activities, and recreational fishing in particular, on coral communities within the reserves (H-KMS)
MCMP: Coral spawn slicks and Coral mass spawning	Brooke Halkyard	DEC	To monitor the timing, location, extent and frequency of coral mass spawning within the Ningaloo Marine Park	Undertake research to develop a cost-effective monitoring protocol to estimate annual coral recruitment within the reserves and investigate the implications for coral reef resilience and connectivity (H-KMS)
MCMP: Mangrove health	Brooke Halkyard	DEC	To monitor the health of mangrove forests in areas of human usage.	Develop and progressively implement an integrated and prioritised ecological and social monitoring program for the reserves with a particular emphasis on MPRA and CALM audit requirements (H-KMS)
MCMP: Seabird sightings	Brooke Halkyard	DEC	To monitor the number and location of seabird sightings within the Ningaloo Marine Park	Undertake research to characterise bird distribution and abundance in the reserves (High)
MCMP: Targeted tropical fish species	Brooke Halkyard	DEC	To monitor and record the presence/absence and location of target fish species within the Ningaloo Marine Park.	Develop and progressively implement an integrated and prioritised ecological and social monitoring program for the reserves with a particular emphasis on MPRA and CALM audit requirements (H-KMS)

Title	DEC contact	Institution	Objectives	Management strategy
MCMP: Water quality	Brooke Halkyard	DEC	To monitor water temperature and clarity at key locations within the Ningaloo Marine Park.	Develop and progressively implement an integrated and prioritised ecological and social monitoring program for the reserves with a particular emphasis on MPRA and CALM audit requirements (H-KMS)
Ningaloo Turtle Monitoring Program	Cath Samson	DEC, WWF; Cape Conservation Group	To monitor relative changes in turtle nest numbers, visitor disturbance rates and predation rates at key rookeries in NMP. Includes education, communication and community participation.	Determine the location and relative significance of turtle aggregation sites and rookeries within the reserves (H-KMS). Ensure interaction activities do not impact on turtles, through education and compliance programs, liaison with charter operators and appropriate licensing (H-KMS). Continue turtle monitoring programs within the reserves (H-KMS).
Seabird Monitoring along the coast of NMP			This project proposes to update the seabird monitoring program along the Ningaloo coast by implementing a consistent methodology which is based upon local research, and is scientifically sound yet operationally efficient	Undertake research to characterise bird distribution and abundance in the reserves (High)
Whale Shark Monitoring	Roland Mau	DEC, Australian Institute of Marine Science; ECOCEAN	To implement the Whale Shark Management Program (No.27)	Continue to implement the Whale shark Interaction Management Program (No. 27) (H-KMS) Continue research on the local and regional migratory patterns of whale sharks and the behavioral response of whale sharks to nature-based tourism (M)
Whale Shark photo ID collection program	Emily Wilson	DEC, Tourism Industry (ECOCEAN and AIMS)	To determine Whale Shark numbers at Ningaloo Marine Park by working with whale shark industry videographers to collect footage - part of the Whale Shark Management Program	Continue research on the local and regional migratory patterns of whale sharks (M)

Table 3.5 Proposed Research Projects

Principle Researcher	Title	Institution	Contact details	Comments
Cecile Rouseaux	Quantifying impacts of the Leeuwin current on the ecology and biogeochemistry of the Ningaloo Reef	UWA	rousseau@sese.uwa.edu.au	PhD student, Dr Anya Waite supervisor
Ceh, Janja	The role of microbial communities in reef building corals along the Ningaloo Reef, WA	Murdoch	j.ceh@murdoch.edu.au	PhD student, Dr Mike Van Keulen supervisor
Collins, Lindsay	Assessment of groundwater system and subterranean aquatic fauna	Curtin	l.collins@curtin.edu.au; 9266 7968	WAMSI project 3.10, proposal being developed
Holley, Dave	Dugong research along the NW cape to NT border	ECU	d.holley@ecu.edu.au	Proposal being developed 2007 To determine the abundance, distribution, movements and critical habitat use of dugong in the region
Langdon, Mark	Investigating the relationship between herbivory and community structure on fringing reef and seagrass meadows at Ningaloo Marine Park	Murdoch	m.langdon@murdoch.edu.au	PhD student, Dr Mike Van Keulen supervisor
Paling, Eric	Characterisation of water and sediment quality.	Murdoch	E.Paling@murdoch.edu.au	WAMSI project 3.3 Proposal stil being prepared
Roberts, Rebecca	Economic strategies for disaster risk-reduction in coastal areas: a case study of Exmouth Gulf	Murdoch	r.roberts@murdoch.edu.au	PhD student, Dr Lynnath Beckley supervisor
Waples, Kelly	Assessment of the effectiveness of large marine fauna monitoring programs: marine turtles		kelly.waples@dec.wa.gov.au	WAMSI project 3.11 proposal being developed
Wenziker, Kristel	The population dynamics and habitat usage of the Indo-pacific humpback dolphin (*Sousa chinensis*) and bottlenose dolphin (*Tursiops truncatus*) found in the Ningaloo Marine Park	Murdoch	kristelw@bigpond.com	PhD student, Dr Mike Van Keulen supervisor

Table 3.6 Research Projects completed since Armstrong 2006.

* Management strategy refers to the management strategies relating to research and monitoring activities for *ecological values* only detailed in the Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005-2015. Application to management strategies for social values have yet to be assessed. The reference system used in this table is adopted from the NMP Research and Monitoring Plan which is attached as Appendix 1.   Strategy priority is also included (H-KMS – High Key Management Strategy, H- High, M – Medium, L- Low).

PI	Title	Institution	Research Team	Mgmt Strategy*	Communication Products	Contact details	Comments
Babcock, Russ	Ningaloo research program start-up project for impacts of human usage, oceanography and management strategy evaluation	CSIRO	Russ Babcock (CSIRO), Ben Fitzpatrick (UWA), Emily Twiggs (Curtin)	R3 (HKMS), R12 (HKMS), M1(HKMS), R11 (HKMS), M5 (HKMS)	Final Report submitted to WAMSI	russ.babcock@csiro.au	
Brinkman, Richard	Ningaloo Research Program start-up project for physical oceanography of the Ningaloo Marine Park	CSIRO	Graham Symonds - CSIRO, Chari Pattiatatchi - UWA	R14, R45	Final Report submitted to WAMSI	r.brinkman@aims.gov.au	
Collins, Lindsay	Climate change and coastal zone management of Carnarvon and Ningaloo Coast	Curtin	STCRC	R17 (H)	Report provided to the Sustainable Tourism CRC	l.collins@curtin.edu.au; 9266 7968	
Collins, Lindsay	Ningaloo Coastal Management Project	Curtin			Report provided to the DEC, including results of 3 honours Theses, some work continues with the Cluster	l.collins@curtin.edu.au; 9266 7968	
Featherstone, William	Prediction of sea level change around Australia and its calibration and validation by satellite-geodetic measurements	Curtin Uni, WACG		R17 (H)		W.Featherstone@curtin.edu.au (08) 9266 2734	Near completion, see publication list on www.cage.curtin.edu.au/~will/

PI	Title	Institution	Research Team	Link to MPMP	Communication Products	Contact details	Comments
Heyward, Andrew	Ningaloo Research Program start-up project for habitat and biodiversity surveys in the deep waters of the Ningaloo Marine Park.	AIMS	Jane Fromont - WAM, Ben Fitzpatrick, Euan Harvey - UWA, Emily Twiggs, Lindsay Collins - Curtin,	R16(H), R4 (HKMS), R21 (H), R7, R10, R6	Final report submitted to WAMSI	a.heyward@aims.gov.au	
Lee, Sam	Hydrogeology of the fractured and karst Tertiary limestone of aquifers of Cape Range focusing on the Water Corporation borefield in Exmouth	Curtin		R39 (M)	PhD Thesis, Curtin	Sam.Lee@curtin.edu.au (08) 9266 3421	
Parker, Justin	Foraminifera from Ningaloo Reef, Western Australia: Systematics and taxonomy	UWA, geology			PhD thesis, UWA	dwhaig@cyllene.uwa.edu.au	Justin works for Geoscience Australia and will be submitting two major monographs and some journal articles based on his thesis
Shiell, GR	Aggregations of the commercial sea cucumber *Holothuria whitmaei* on Ningaloo Reef	UWA			PhD thesis, UWA		PhD Completed
Smith, Leanne	Evaluating the effectiveness of the Jurabi Turtle Centre	Murdoch		M2 (HKMS)	Honours Thesis, Murdoch	astraphobic@hotmail.com	Honours project, Murdoch, supervisor David Newsome

PI	Title	Institution	Research Team	Link to MPMP	Communication Products	Contact details	Comments
Travers, Michael	Composition of fish fauna in offshore waters of the Pilbara Kimberley coast	Murdoch			Travers, MJ, Newman, SJ an Potter IC. 2006. Influence of latitude, water depth, day vs night and wet vs dry periods on the species composition of reef fish communities in tropical Western Australia,. Journal of Fish Biology 69(4) 987-1017; FRDC Report 2000/132; further papers submitted on the species compositions of the ichthyofaunas of Exmouth Gulf and highlights the composition of fish assemblages in a heavily trawled environment		Final FDRC report completed. PhD project, Ian Potter, Steve Newman supervising Other papers in prep, including one on species composition of ichthyofaunas of Exmouth Gulf, a heavily trawled environment.
Underwood, Jim	Larval dispersal, gene flow and disturbance in two coral species in northern WA	UWA, AIMS	Madelaine VanOppen (AIMS), James Gilmour (AIMS), Luke Smith (AIMS), Mike Johnson (UWA)		PhD thesis, UWA	underj01@student.uwa.edu.au (08) 6488 1483	PhD project, supervisor Mike John son UWA, Luke Smith, AIMS, Madeline Van Oppen AIMS
Uniquest	Impacts of Commercial Shipping on Ningaloo Marine Park (Commonwealth Waters)	Uniquest (UQ)					
Walker, D	Key informant survey on whale shark tourism management Ningaloo Marine Park, WA	James Cook Uni		M12 (H)	Masters Thesis, JCU	d.walker@gbrmpa.gov.au	

PI	Title	Institution	Research Team	Link to MPMP	Communication Products	Contact details	Comments
Webster, Fiona	Effect of algae, herbivores and nutrients on the settlement and survival of coral	Murdoch		7.1.4 (KPI)/ 2 (H-KMS), 13, (H)	Annual reports; conference proceedings; 2 Awards; Research complete, finalising thesis		Research completed, PhD near completion, Mike Van Keulen supervisor

4. APPENDICES

APPENDIX I   Extract from the Ningaloo Marine Park Research and Monitoring Plan

THE NINGALOO MARINE PARK RESEARCH AND MONITORING PLAN

Marine Conservation Branch
Department of Conservation and Land Management
47 Henry St. Fremantle, Western Australia, 6160

January 2005

Background

The Ningaloo Marine Park Management Plan (1989-1999) was due for review in 2000. As well as revising the management arrangements for the existing Ningaloo Marine Park, the review process considered a southern extension of the Ningaloo Marine Park to Red Bluff on Quobba Station with the purpose of including all of the Ningaloo Reef within the Park. In addition, the review process considered the establishment of a marine conservation reserve around the Muiron Islands, immediately to the north of the existing marine park.

The Ningaloo Marine Park Draft Management Plan for the existing Park and the Indicative Management Plan for the southern extension to the Park and the Muiron Islands Marine Management Area (hereafter known collectively as 'the draft plan') were released by the Premier on the 26 July 2004 for a three month statutory public submission period. At the same time The Premier announced that the Government would allocate $5M over four years to a Ningaloo Research Fund. The Ningaloo Research Fund is to be used to improve the scientific basis for the conservation and management of the Ningaloo region through a well integrated program of scientific research (Appendix I). The release of the Draft Management Plan for public comment and the announcement of the Ningaloo Research Fund provided an opportunity for a consolidated program of research and monitoring to be developed and incorporated into the Ningaloo Marine Park Management Plan 2005-2015.

Introduction

A comprehensive science knowledge base is necessary for the conservation and effective management of human use of the Ningaloo Marine Park. An understanding of the biodiversity values or assets, the natural processes that influence, and the anthropogenic processes that threaten these values, as well as the efficacy of management strategies to manage human use should collectively underpin management decision-making. Because the existing information base to support current decision-making is limited, the acquisition of new information is a key strategy in developing the revised management arrangements for the Ningaloo Marine Park.

The Ningaloo Marine Park Research and Monitoring Plan identifies and prioritises research and monitoring strategies that will address the information requirements for conservation and sustainable management of human use in the Ningaloo Marine Park over at least the next decade. These requirements are directed at improving knowledge and reducing uncertainty about marine ecosystem function (research) and the implications of human use of these natural resources. They are also targeted at detecting changes in the system, then relating these changes to the management of pressures so as to refine future decisions (via monitoring or performance assessment). The plan aims to provide research providers with clear guidance on funding priorities for research and monitoring.

Identification and prioritisation of research and monitoring strategies

The Ningaloo Marine Park Research and Monitoring Plan presents marine research and monitoring strategies that have been identified and prioritized using a framework developed by the Department of Conservation and Land Management's (the Department's) Marine Conservation Branch (MCB) (Simpson et al., 2002). The framework uses a combination of the relative significance of the ecosystem values/attributes (V), pressures (P) and the adequacy of existing knowledge (K). These metrics provide a value-pressure-knowledge ranking matrix to identify priority research and monitoring strategies. In the absence of available quantitative data on V, P, and K, scoring for each criterion is dependent on the expertise, knowledge and experience of the people involved in the assessment process. The initial research and monitoring strategies were developed through an 'in house' workshop that applied the above framework.

Strategies identified through this prioritisation framework were incorporated within the draft plan. The release of the draft plan for public comment enabled the public, stakeholders and, in particular, research organizations and institutions to provide comment on the nature and priority of the research and monitoring strategies outlined in the draft plan and to recommend additional strategies for inclusion within the plan. This essentially provided an expert group approach to the identification of research and monitoring strategies. To ensure the revised strategies reflected management information requirements, they were subject to assessment against the following decision rules.

A research and monitoring strategy was not included if:
- It was not considered relevant to park management;
- It proposed a R&M strategy at a level of detail that is already encompassed within a broader strategy; or
- It did not fall within the research or monitoring category or was of an administrative nature only.

Submissions provided by research organisations were subsequently reviewed and the relevant research and monitoring strategies compiled.

With limits to the available resources for research and monitoring, strategies were then assessed as high, medium or low priority for effective park management.
- For fundamental research strategies, a high priority rating focuses on existing gaps in knowledge such as inventory and baseline information. They are to contribute to an improved understanding of natural systems and the key process that determine their structure and function that is required for effective management.
- For applied research strategies, a high priority rating must target significant values (including the Key Performance Indicators) that are poorly understood and subject to human pressure. It may include research on the nature, level and future trends in human activities and the consequences this presents for conserving biodiversity.
- For monitoring strategies, a high priority rating needs to contribute to the development of monitoring protocols for a significant value (eg performance indicators, sampling design, surrogates) and provide an improved capacity to detect changes in the status or condition of a significant value. They may also support investigations into the implications of these changes for management (eg acceptable limits of use, management targets).

In addition, strategies that are considered to be critical to conserving the key values and achieving the management objectives for the MCR are designated as 'high priority Key Management Strategies' (H-KMS). Strategies relating to the Key Performance Indicators may be identified as high, medium or lower priority.

Management responsibilities
All marine conservation reserves, established under the CALM Act, are vested in the Marine Parks and Reserves Authority (MPRA), a non-government independent statutory authority. Apart from CALM other State Government agencies have responsibilities in the implementation of the management plan for the Ningaloo Marine Park. Examples include the Department of Fisheries (DoF), Department of Planning and Infrastructure (DPI) and the Department of Industry and Resources (DOIR). Strategies in the management plan are followed by acronyms of the agencies that have responsibilities for the implementation of the strategies.

Glossary of Key Terms

Priority Rankings for Research and Monitoring Strategies	
H	High
M	Medium
L	Low

KPI	Key Performance Indicators provide a measure of the overall effectiveness of management in relation to the strategic objectives of the reserve. They are a key element of the MPRA audit process
KMS	Key Management Strategy. KMS' are considered critical to achieving the long-term objectives of the reserves and are designated a High priority strategy.

AMSA	Australian Maritime Safety Authority
AIMS	Australian Institute of Marine Science
CALM	The Department of Conservation and Land Management
CSIRO	The Commonwealth Science and Industry Research Organisation
ECU	Edith Cowan University

DEH	Department of Environment and Heritage (Commonwealth)
DIA	Department of Indigenous Affairs
DoE	The Department of Environment
DoF	The Department of Fisheries
DoIR	The Department of Industries and Resources
DPI	The Department of Planning and Infrastructure
Murdoch Uni	Murdoch University
WAM	Western Australian Museum
WAMM	Western Australian Maritime Museum
Curtin Uni	Curtin University
LGA	Local Government Authority
UWA	The University of Western Australia

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Appendix

Table 1: RESEARCH AND MONITORING STRATEGIES FOR THE NINGALOO MARINE PARK

Research and monitoring strategies are identified for ecological and social values of the Ningaloo Marine Park. Each strategy is assigned a priority ranking (High-**H**, Medium-**M** or Low-**L**). The relevance of these strategies to park management is briefly explained (column 3) and institutions with a potential interest in conducting the work are identified (column 4). Each strategy is assigned a unique alphanumeric identifier that serves to cross-reference strategies with those listed in Table 2.

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
Geomorphology	• Undertake research to map and classify the seabed geomorphology of the reserves, with a particular emphasis on the deeper (>20m) areas and reserve areas of Exmouth Gulf. (CALM). (H) [R-13]	Will assist in broad scale mapping of deeper water biodiversity values and contribute to the identification of biodiversity surrogates.	AIMS Curtin Uni. WAM UWA
	• Undertake research to improve knowledge of the coastal groundwater system and its relationship to the reef system. (CALM) (M)[R-39]	Will improve understanding of the geomorphology and hydrology of the reserve and the adjacent coast and assist in the development of management targets.	
	• Undertake research to investigate the morphology and growth history of the reef system and identify the importance of reef growth characteristics for the maintenance of reef biodiversity. (CALM) (L) [R-51]	Will provide a better understanding of reef condition and natural variability over evolutionary timescales.	
Sediment quality	• Undertake contaminant sediment surveys in designated mooring and anchoring areas and at appropriate control sites, particularly in relation to hydrocarbons and antifouling paint contamination (CALM). (M)[R-40]	Will determine the condition of sediments in high boat use areas of the reserves and identify the need for remedial action. Will provide baseline conditions for key contaminants for future reference.	DoE CALM
	• Undertake research to characterise the surficial sediments of the shallow waters (<20 m) of the reserves (CALM). (M) [R-41]	Will provide a better description of sediment characteristics and assist interpretation of sediment 'infauna' and contaminant studies.	
Water quality (KPI)	• Map the ecological and social values of the reserves that are highly sensitive to oil spills and ensure this information is accessible to the State Committee for Combating Marine Oil Pollution (CALM, DPI). (H)[R-15]	Will assist decision-making in relation to emergency responses to accidental oil spills.	DoIR AMSA UWA

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• Develop an appropriate understanding and predictive capacity of the circulation and mixing of the reserves' waters, particularly in relation to key ecological processes (eg nutrient supply and productivity, recruitment, connectivity) (CALM). (H)[R-14]	Will assist in the interpretation of water and sediment quality studies; will support key ecological investigations (e.g. coral and fish recruitment); will assist decision-making in relation to emergency responses to oils spills; will assist in managing visitor risks.	Curtin Uni.
	• Undertake water quality surveys at appropriate control sites and in areas of the reserves that are, or have been, exposed to contaminant inputs (CALM). (M)[M-17]	Will identify areas of NMP that are 'at risk' from contaminant inputs and assess the contaminant status of the water in high use areas. Will identify the need for remedial action as well as providing baseline conditions for key contaminants for future reference.	
	• Undertake a baseline litter survey in areas of historical and current high use (CALM). (M)[M-16]	Will determine the status of litter in high use areas and the need for remedial action.	
Coral reef communities (KPI)	• Undertake research to characterise the distribution, abundance and key functional groups of coral populations within the reserves, with a particular emphasis on the seaward deeper water communities (CALM). (H)[R-16]	Will provide a better understanding of coral reef community ecology and the role of key functional groups in maintaining healthy coral reef systems.	AIMS CSIRO Curtin Uni. DoF ECU Murdoch Uni.
	• Assess the nature, level and potential impact of human activities, and recreational fishing in particular, on coral communities within the reserves (CALM, DoF). (H)[M-6]	Will assist in identifying coral reef areas of NMP that are 'at risk' from human activities. Will provide a better understanding of the 'carrying capacity' of NMP in relation to the future levels of human use.	
	• Undertake research to assess the potential impacts of climate change on Ningaloo Marine Park over the next 50 years, with particular emphasis on the coral reef communities (CALM). (H)[R-17]	Will provide managers with an understanding of the potential effects of climate change and enable them to adapt management of the reserve accordingly.	
	• Monitor coral communities in areas at most risk of mooring and anchoring damage and review the effectiveness of anchoring restrictions in preventing coral damage (CALM). (M)[M-18]	Will provide information on the need for, nature and timing of intervention strategies to minimise human impacts.	

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• Undertake research and monitoring to assess the ecosystem effects of recreational fishing on coral reef communities (i.e. trophic cascades) (CALM, DoF). (H-KMS)[R-3]	Will assist in determining the ecosystem effects of recreational fishing on coral reef ecology and identify the need for further management of this activity.	
	• Monitor the recovery of the coral reef communities in Bills Bay every three years (CALM). (H)[M-7]	Will provide important information on the nature and timescale of recovery dynamics of coral reef communities in NMP.	
	• Undertake research for the development of cost-effective monitoring protocols to estimate coral recruitment within the reserves and investigate the implications for coral reef resilience and connectivity (CALM). (H-KMS) [R-1]	Will provide the scientific basis for the long-term monitoring of key ecological processes.	
	• Undertake research to develop cost-effective monitoring protocols to estimate coral reef fish recruitment within the reserves and investigate the implications for coral reef resilience and connectivity. (CALM). (H-KMS) [R-2]	Will provide the scientific basis for the long-term monitoring of key ecological processes.	
	• Monitor the distribution and abundance of *Drupella cornus* in the reserves at least every three years (CALM). (H)[M-8]	Will provide updated population status and trends in a key coral predator in NMP; better understanding of natural variability.	
	• Undertake research with the aim of developing cost-effective protocols to monitor *Drupella cornus* population trends in the reserve (CALM). (H)[R-18]	Will provide the scientific basis for the long-term monitoring of *Drupella* population dynamics	
	• Undertake research on the distribution and abundance of key predators of *Drupella cornus* (CALM). (H)[R-19]	Will facilitate a better understanding of the potential links between human activities (e.g. fishing), predator abundance and coral predation by *Drupella*.	
Filter-feeding communities (other than corals)	• Undertake research to characterise the distribution and abundance of filter feeding communities in the reserves, particularly in the deeper offshore waters and in the areas of the reserves subject to trawling activities (CALM). (H-KMS)[R-4]	Will provide a better understanding of the distribution, abundance and conservation status of filter-feeding communities in the reserves; and determine the resilience of these communities to trawling activities.	AIMS Curtin Uni. ECU. DoF Murdoch Uni. UWA
	• Undertake further research with the aim of developing cost-effective monitoring protocols to determine the 'health' of filter-feeding communities (CALM). (M)[R-42]	Will provide the scientific basis for the long-term monitoring and management of these key ecological communities.	

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
Shoreline intertidal reef communities	• Assess the nature, level and potential impacts of human activities on shoreline intertidal reef communities within the reserves (CALM). (H-KMS)[M-1] • Monitor shoreline intertidal reef communities in areas at most risk of degradation from human activities such as trampling (CALM). (H)[M-9] • Undertake research to characterise the flora and fauna on representative shoreline intertidal reef communities within the reserves (CALM). (H)[R-20]	Will identify the frequency and types of human activities with the potential to impact on intertidal areas. Will identify sensitive intertidal reef communities and their vulnerability to levels of disturbance from human activity. Will improve knowledge of community structure and function of intertidal reef communities. Will contribute to the identification of performance indicators and management targets for intertidal reef communities	AIMS Curtin Uni. ECU. DoF Murdoch Uni. UWA
Soft sediment communities	• Undertake research to better characterise the flora, fauna and distribution of soft sediment communities within the reserves, particularly in the deeper offshore waters of the Park and in Exmouth Gulf (CALM). (H)[R-21] • Assess the nature, level and potential impacts of human activities on soft sediment communities within the reserves and if appropriate, implement management activities to minimise these impacts (CALM, DoF). (M)[M-19]	Will improve understanding of the spatial ecology of soft sediment communities and underpin the development of a soft sediment habitat classification scheme Will identify key threatening processes and existing levels of disturbance to soft sediment communities and assist in the development of key performance indicators and management targets.	Curtin Uni. ECU. DoF Murdoch Uni. UWA WAM
Macroalgal and seagrass communities	• Undertake research to better characterise the diversity, distribution and abundance of seagrass and macroalgal communities within the reserves (CALM, DoF). (H)[R-22] • Undertake research to characterise the level and nature of herbivory in the reserves and use this information to assist in the development of a monitoring protocol for this key process (CALM). (H-KMS)[R-5]	Will improve understanding of key ecological processes affecting seagrass and macroalgal community structure and function. Will improve understanding of trophic dynamics and linkages between key ecological components, predator-prey interactions and mapping of seagrass and macroalgal productivity	Curtin Uni. ECU. Murdoch Uni. UWA
Mangrove communities (including mudflats) (KPI)	• Undertake research to characterise the flora and fauna of the mangals and mudflats within the Park (CALM). (H)[R-23]	Will improve understanding of the ecology and productivity of mudflat and mangal environments and underpin the development of a habitat classification scheme to map spatial heterogeneity and	Curtin Uni. ECU. DoF Murdoch Uni. UWA

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
		productivity. Will assist in the development of performance indicators, management targets and protection strategies to minimise disturbance from human activities.	
Coastal biological communities (KPI)	• Assess the nature, level and potential impacts of human activities on coastal biological communities within the reserves (CALM). (H)[M-10] • Determine the impact of built structures and their associated use, within the 40m strip, on the coastal biological communities and review the effectiveness of management strategies (CALM). (L)[R-52] • Initiate research programs to characterise the flora and fauna of representative coastal areas within the reserves in relation to determining management targets (CALM). (M)[R-43]	Will quantify the frequency and types of human activities with the potential to impact coastal biological communities. Will identify coastal biological communities sensitive to human disturbance and assist in the development of protection strategies. Will improve understanding of linkages between coastal and maritime biological communities	AIMS CSIRO Curtin Uni. DoE DoF Murdoch Uni. UWA
Seabirds and migratory waders	• Undertake research to characterise seabird distribution and abundance in the reserves (CALM). (H)[R-24]	Will improve understanding of seabird and wader population status and trends and the importance of key habitats in maintaining demographic processes.	CALM WAM
Finfish (KPI)	• Undertake research to better characterise finfish diversity and abundance in the reserves and support the development of management targets for commercial and recreational target fish species. (CALM, DoF). (H-KMS)[R-6] • Undertake research to identify aggregation and spawning sites and times for key finfish species (CALM, DoF). (H)[R-25]	Will improve knowledge of finfish diversity and population trends and will contribute to the development of key performance indicators and management targets. Will improve knowledge of the effect of spatial closures on finfish populations Will improve understanding of finfish population dynamics and spatial ecology.	AIMS Curtin Uni. ECU DoF Murdoch Uni. UWA
	• Quantify the level and significance of by-catch for recreational and commercial fishing activities in the reserves. (DoF, CALM). (M)[M-20]	Will improve understanding of the level and distribution of fishing effort within the reserve and identify impacts to non-target species.. Will improve understanding of the trophic linkages of exploited species to other ecosystem components.	

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• Undertake research, with the aim of developing a cost-effective monitoring protocol, to estimate annual recruitment of key targeted fish species in the reserves (CALM, DoF). (H) [R-26]	Will provide the scientific basis for the long-term monitoring of this key ecological process..	
	• Undertake research on pelagic fishes to examine benthic-pelagic coupling. (CALM). (H)[R-27]	Improve knowledge of the linkages between the benthos and the overlying water body (ie through key processes such as grazing, particle deposition and sediment resuspension) and the significance of this process for marine ecosystem dynamics.	
Invertebrates (mobile)	• Undertake research programs to characterise invertebrate diversity, distribution and abundance in the reserves and to support the development of management targets for commercial and recreational target invertebrate species (CALM, DoF). (H-KMS)[R-7]	Will provide baseline information for future reference; assist in the development of management targets. Will determine the conservation status of targeted species and support sustainable management practices. Will support integrated fisheries management through the development of protection strategies for non-targeted species.	AIMS Curtin Uni. ECU DoE DoF Murdoch Uni. UWA
Sharks and rays	• Undertake research to characterise shark/ray diversity and abundance in the reserves and support the development of management targets for shark and ray species. (CALM, DoF) (H-KMS) [R-8]	Will improve understanding of the population status and trends. Will provide a scientific basis to identify performance measures, management targets and a monitoring program to inform the development of protection strategies.	AIMS Curtin Uni. ECU DoF Murdoch Uni. UWA
	• Undertake research to better document shark/ray movement patterns and aggregations within the reserves. (CALM, DoF). (H)[R-28]	Will improve management of threatening processes by providing information on shark/ray distributions across the reserve. Will improve understanding of key ecological processes influencing shark and ray population dynamics.	
Whale sharks	• Continue research on the local and regional migratory patterns of whale sharks (CALM). (M)[R-44]	Will improve understanding of whale shark ecology	DEH Murdoch Uni.

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• Continue biological oceanographic research to establish the relationship of spatial and temporal patterns in biophysical variables (eg temperature, nutrients, zooplankton, habitat) important to whale shark aggregation and migration (CALM). (M)[R-45] • Monitor the behavioural response of whale sharks to nature-based activities (CALM). (M) [M-20]	Will support management's information requirements through the delivery of timely research on whale shark behaviour and population trends Will evaluate the effectiveness of management strategies in minimising human disturbance on whale shark behaviour and support ongoing management of whale shark/human interactions	UWA AIMS
Manta rays	• Undertake research on the general ecology of manta rays with the aim to determine potential impacts of human interaction on manta populations (CALM). (H)[R-29]	Will improve understanding of manta ray population status and trends. Will provide a better understanding of threatening processes and the vulnerability of manta rays to human activities.	Murdoch Uni. UWA WAM
Whales and dolphins	• Monitor the behavioural response of whales to nature-based activities such as whale watching and determine the need to review existing management controls in the event of future expansion of the whale watching industry (CALM). (M)[M-22]	Will identify the need for appropriate management controls to minimise disturbance resulting from human/whale interactions	DEH Murdoch Uni. UWA WAM
	• Undertake research to improve understanding of the importance of the region to whale demographics and ecology (CALM). (M)[R-46]	Will improve understanding of key areas for whale conservation.	
Turtles (KPI)	• Determine the location and relative significance of turtle aggregation sites and rookeries within the reserves (CALM). (H-KMS)[R-9] • Evaluate the effectiveness of turtle monitoring programs within the reserves and implement revised/modified turtle monitoring programs as required (CALM). (H-KMS)[M-2] • Undertake research to determine the status and trends of the turtle populations in the reserves in relation to historical populations (CALM). (H)[R-30] • Maintain records of the incidence of by-catch of turtle species within and adjacent to the Park (CALM, DoF). (H)[M-11]	Will identify ecologically important areas within the reserve and improve understanding of their role in maintaining key demographic processes Will provide the scientific basis for the long-term monitoring of turtle population dynamics. Will improve knowledge of turtle population status and trends and the contribution of on-reserve management to species recovery plans. Will improve understanding of threatening processes and the effectiveness of management responses in minimising disturbance from human activities.	DEH Murdoch Uni. UWA WAM

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• In partnership with the Coral Coast Park Council undertake research to determine the extent and the level of indigenous hunting that is sustainable (CALM, Coral Coast Park Council). (H)[R-31]	Will provide a scientific basis to recommend sustainable levels of indigenous harvest.	
Dugong	• Undertake research to better understand dugong population, distribution and habitat requirements in the reserves and the adjacent areas in Exmouth Gulf and determine the current status of the dugong population in relation to historical levels (CALM). (M)[R-47] • In partnership with the Coral Coast Park Council, undertake research to determine the extent and the level of indigenous hunting that is sustainable (CALM, Coral Coast Park Council). (H)[R-32]	Will improve understanding of key threatening processes and contribute to the development of management strategies to effectively minimise disturbance from human activities. Will improve knowledge of dugong population demographics and habitat requirements. Will provide a scientific basis to recommend sustainable levels of indigenous harvest.	DEH Murdoch Uni. UWA

'PASSIVE' SOCIAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	NSTITUTIONAL INTERESTS
Indigenous heritage	• Develop, in collaboration with the local Aboriginal community, an understanding of the significance of the area to Aboriginal people (CALM, Coral Coast Park Council). (M)[R-48] • Identify, in collaboration with the local Aboriginal community, the significance of indigenous heritage sites in the reserves (CALM, Coral Coast Park Council). (M)[R-49]	Will improve understanding of social and cultural dynamics of indigenous peoples and their relationship with the marine environment Will inform the management of culturally significant areas	DIA DEH DoF WAM
	• Develop, in collaboration with the local Aboriginal community, protocols and a monitoring program for traditional hunting in the reserves (CALM, Coral Coast Park Council). (M)[M-23]	Will provide a scientific basis to monitor key performance indicators and report against management targets to support sustainable levels of indigenous harvest	

'PASSIVE' SOCIAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	NSTITUTIONAL INTERESTS
Maritime heritage	• Develop a cost-effective monitoring strategy for maritime heritage sites within the reserves in cooperation with the maritime museum. (CALM, WAMM). (M)[M-24]	Will provide a scientific basis to monitor maritime heritage sites and will assist in the management of historically and culturally significant areas.	DEH WAMM
Wilderness (KPI)	• Undertake research to characterise 'wilderness' areas of the reserves and develop performance measures and management targets for designated 'wilderness' areas (CALM, LGA) (H)[R-33]	Will provide a scientific basis to map and classify wilderness values of the reserve. Will identify the frequency and types of human activities with the potential to impact on wilderness areas and assist in the development of management targets and strategies.	Curtin Uni.

'ACTIVE' SOCIAL VALUES	RESEARCH STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL INTERESTS
Water sports	• Assess the nature, level, spatial and temporal patterns and potential impacts of water sports in the reserves (CALM). (H-KMS)[M-3]	Will improve understanding of the dynamics of human activities in the reserve over space and time and to identify the need for appropriate management controls	Curtin Uni. ECU Murdoch Uni.
Marine nature-based tourism	• Assess the nature, level and potential environmental impacts of commercial tourism operations within the reserves (CALM). (H)[M-12] • Undertake research to establish appropriate baselines in the Park adjacent to existing and proposed tourism nodes identified in the Carnarvon/Ningaloo Coast Regional Strategy (CALM). (H)[R-34]	Will improve understanding of the dynamics of human activities in the reserve over space and time and to identify the need for appropriate management controls. Will improve understanding of the natural variability of nearshore and coastal biological communities for future benchmarking and management.	Curtin Uni. DoF Murdoch Uni.
Coastal use	• Identify coastal areas of the reserves that are degraded and identify the feasibility of alternative techniques for effective rehabilitation (CALM). (H)[R-35] • Undertake research to map the coastal geomorphology of the park (CALM). (H)[R-36]	Will identify the frequency and types of human activities with the potential to impact on sensitive coastal areas and assist in the development of management strategies. Will support the successful rehabilitation of degraded coastal areas. Will improve understanding of the geomorphology of the reserve and contribute to identification, classification and management of representative coastal habitats.	DPI DoE LGA WAM

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'ACTIVE' SOCIAL VALUES	RESEARCH STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL INTERESTS
Recreational fishing	• Continue to undertake research and monitoring of the ecological effects of recreational fishing in the reserves and review management controls as appropriate (CALM, DoF). (H-KMS)[M-3] • Formulate performance measures and targets for key recreational species that will ensure ecologically sustainable recreational fishing in the reserves (CALM, DoF). (H)[R-37]	Will improve understanding of the ecological effects of recreational fishing (ie trophic cascades) and assist in the development of appropriate management strategies Will apply knowledge of ecological and social systems to assist in the development of performance indicators, management targets and protection strategies to minimise disturbance from human activities.	AIMS Curtin Uni. ECU DoF Murdoch Uni. UWA
	• Monitor the abundance of selected target finfish species to assess effectiveness of management strategies, with a particular emphasis on the effectiveness of the sanctuary zones (CALM, DoF). (H)[M-13] • Monitor and report on recreational fishing catch/effort within the reserves (DoF, CALM). (H)[M-14] • Implement a community monitoring program for key target fish species in the Park (CALM, DoF, LGA). (H)[M-15]	Will improve understanding of the effect of spatial closures on the population dynamics of targeted species. Will improve understanding of the dynamics of fishing effort in response to management controls Will assist in the development of a monitoring program to support management information needs.	
Commercial fishing	• Assess the levels and effects of commercial fishing, particularly the marine aquarium fishery, in the reserves and review the effectiveness of existing management controls (DoF, CALM). (M)[M-25] • Monitor and report on commercial fishing catch/effort within the reserves (DoF). (L)[M-26]	Will provide a better understanding of the impacts of commercial fishing on marine ecosystems and assess the effectiveness of management strategies for the delivery of economic and conservation outcomes. Will improve understanding of the dynamics of commercial fishing effort in response to management controls	Curtin Uni. ECU DoF Murdoch Uni. UWA

GENERIC	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL INTERESTS
Research	• Undertake research of marine fauna and flora to support the development and monitoring of cost-effective reef health indicators (CALM). (H-KMS)[R-10]	Will investigate the role of biodiversity surrogates for performance assessment and identify appropriate indicators.	DoE DoF DIA

GENERIC	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL INTERESTS
	• Undertake research to determine the effectiveness of the zoning scheme for biodiversity conservation and in relation to the CAR principles, with a particular emphasis on Sanctuary Zones. (CALM) (H-KMS)[R-11]	Will support the development of a framework for evaluating management effectiveness at the value, park and system level. Will lead to better understanding of community ecology, threatening processes and sustainable limits of use.	AIMS CSIRO Curtin Uni. ECU Murdoch Uni. UWA WAM
	• Undertake research to determine the effectiveness of the zoning scheme for integrated management of targeted fish stocks in the marine reserves, with a particular emphasis on Sanctuary Zones. (CALM) (H-KMS)[R-12]	Will support the development of an integrated management framework for fisheries management and biodiversity conservation. Will inform the development and implementation of sustainable fishing practices.	
	• Investigate the applicability and benefits of implementing a management strategy evaluation approach to support performance assessment and adaptive management (CALM). (H)[R-38]	Will investigate the feasibility of MSE approaches for management of the reserves.	
	• Undertake research into the history of marine animal populations in the reserves. (CALM, DoF) (M)[R-50]	Will improve understanding of population trends through time and provide context for current marine species assessments.	
Monitoring	• Implement a long-term monitoring program, commencing with baseline studies, to assess the effectiveness of the sanctuary zone scheme (CALM). (H-KMS)[M-5]	Will underpin effective management of the reserves. Will ensure the collection and compilation of information at a resolution that supports best practice management. Will improve understanding of natural variability and key ecological processes that underpins ecosystem health. Will improve understanding of the resilience of biological communities to natural events and human disturbances.	DEH DoE DoF AIMS CSIRO Curtin Uni. ECU Murdoch Uni. UWA WAM

Table 2: RESEARCH AND MONITORING STRATEGIES GROUPED BY PRIORITY RATING FOR THE NINGALOO MARINE PARK

Research and monitoring strategies are separated into research strategies and monitoring strategies then grouped according to their management priority ratings (High Key Management Strategy-**H-KMS**, High-**H**, Medium-**M** or Low-**L**). Within each priority grouping, strategies appear in order of the ecological and social values of the Ningaloo Marine Park Management Plan. The alphanumeric value that precedes each strategy serves as a cross-reference to strategies in Table 1. Shading indicates that research consistent with that strategy is reported in the Current Research Database (Table 3).

Management Priority	RESEARCH STRATEGIES
H-KMS	R-1. Undertake research for the development of cost-effective monitoring protocols to estimate coral reef recruitment within the reserves and investigate the implications for coral reef resilience and connectivity (CALM) (KMS-Coral reef communities).
	R-2. Undertake research to develop cost-effective monitoring protocols to estimate coral reef fish recruitment within the reserves and investigate the implications for coral reef resilience and connectivity. (CALM) (KMS-Coral reef communities).
	R-3. Undertake research and monitoring to assess the ecosystem effects of recreational fishing on coral reef communities (i.e. trophic cascades). (CALM, DoF) (KMS-Coral reef communities).
	R-4. Undertake research to characterise the distribution and abundance of filter feeding communities in the reserves, particularly in the deeper offshore waters and in the areas of the reserves subject to trawling activities (CALM) (KMS-Filter Feeding)
	R-5. Undertake research to characterise the level and nature of herbivory in the reserves and use this information to assist in the development of a monitoring protocol for this key process. (CALM) (KMS-Macroalgal & Seagrass)
	R-6. Undertake research to better characterise finfish diversity and abundance in the reserves and support the development of management targets for commercial and recreational target fish species. (CALM, DoF) (KMS-Finfish)
	R-7. Undertake research programs to characterise invertebrate diversity, distribution and abundance in the reserves and to support the development of management targets for commercial and recreational target invertebrate species (CALM, DoF) (KMS-Invertebrates)
	R-8. Undertake research to characterise shark/ray diversity and abundance in the reserves and support the development of management targets for shark and ray species. (CALM, DoF) (Sharks & rays)
	R-9. Determine the location and relative significance of turtle aggregation sites and rookeries within the reserves. (CALM) (KMS-Turtles)
	R-10. Undertake research of marine fauna and flora to support the development and monitoring of cost-effective reef health indicators (CALM) (KMS-Research)
	R-11. Undertake research to determine the effectiveness of the zoning scheme for biodiversity conservation and in relation to the CAR principles, with a particular emphasis on Sanctuary Zones. (CALM) (KMS-Research)
	R-12. Undertake research to determine the effectiveness of the zoning scheme for integrated management of targeted fish stocks in the marine reserves, with a particular emphasis on Sanctuary Zones. (CALM, DoF) (KMS-Research)
H	R-13. Undertake research to map and classify the seabed geomorphology of the reserves, with a particular emphasis on the deeper (>20m) areas and reserve areas of Exmouth Gulf. (CALM) (Geomorphology)
	R-14. Develop an appropriate understanding and predictive capacity of the circulation and mixing of the reserves' waters, particularly in relation to key ecological processes (eg nutrient supply and productivity, recruitment, connectivity). (CALM) (Water

Management Priority	RESEARCH STRATEGIES
H	Quality)

R-15. Map the ecological and social values of the reserves that are highly sensitive to oil spills and ensure this information is accessible to the State Committee for Combating Marine Oil Pollution (CALM, DPI) (Water Quality).

R-16. Undertake research to characterise the distribution, abundance and key functional groups of coral populations within the reserves, with a particular emphasis on the seaward deeper water communities (CALM) (Coral reef communities)

R-17. Undertake research to assess the potential impacts of climate change on Ningaloo Marine Park over the next 50 years, with particular emphasis on the coral reef communities (CALM) (Coral reef communities).

R-18. Undertake research with the aim of developing cost-effective protocols to monitor *Drupella cornus* population trends in the reserve. (CALM) (Coral reef communities)

R-19. Undertake research on the distribution and abundance of key predators of *Drupella cornus*. (CALM) (Coral reef communities)

R-20. Undertake research to characterise the flora and fauna on representative shoreline intertidal reef communities within the reserves (CALM) (Intertidal reef communities)

R-21. Undertake research to better characterise the flora, fauna and distribution of soft sediment communities within the reserves, particularly in the deeper offshore waters of the Park and in Exmouth Gulf (CALM) (Soft sediment communities)

R-22. Undertake research to better characterise the diversity, distribution and abundance of seagrass and macroalgal communities within the reserves (CALM, DoF) (Macroalgal & Seagrass)

R-23. Undertake research to characterise the flora and fauna of the mangals and mudflats within the Park (CALM) (Mangrove)

R-24. Undertake research to characterise seabird distribution and abundance in the reserves. (CALM) (Seabirds)

R-25. Undertake research to identify aggregation and spawning sites and times for key finfish species. (CALM, DoF) (Finfish)

R-26. Undertake research, with the aim of developing a cost-effective monitoring protocol, to estimate annual recruitment of key targeted fish species in the reserves. (CALM, DoF) (Finfish)

R-27. Undertake research on pelagic fishes to examine benthic-pelagic coupling. (CALM) (Finfish)

R-28. Undertake research to better document shark/ray movement patterns and aggregations within the reserves. (CALM, DoF) (Sharks & rays)

R-29. Undertake research on the general ecology of manta rays with the aim to determine potential impacts of human interaction on manta populations (CALM) (Manta rays)

R-30. Undertake research to determine the status and trends of the turtle populations in the reserves in relation to historical populations (CALM) (Turtles)

R-31. In partnership with the Coral Coast Park Council undertake research to determine the extent and the level of indigenous hunting that is sustainable. (CALM, Coral Coast Park Council) (Turtles)

R-32. In partnership with the Coral Coast Park Council, undertake research to determine the extent and the level of indigenous hunting that is sustainable. (CALM, Coral Coast Park Council) (Dugong)

R-33. Undertake research to characterise 'wilderness' areas of the reserves and develop performance measures and management targets for designated 'wilderness' areas (CALM, LGA) (Wilderness)

R-34. Undertake research to establish appropriate baselines in the Park adjacent to

Management Priority	RESEARCH STRATEGIES
H	existing and proposed tourism nodes identified in the Carnarvon/Ningaloo Coast Regional Strategy. (CALM) (Marine nature-based tourism)
	R-35. Identify coastal areas of the reserves that are degraded and investigate the feasibility of alternative techniques for effective rehabilitation (CALM) (Coastal use)
	R-36. Undertake research to map the coastal geomorphology of the park. (CALM) (Coastal use)
	R-37. Formulate performance measures and targets for key recreational species that will ensure ecologically sustainable recreational fishing in the reserves. (CALM, DoF) (Recreational fishing)
	R-38. Investigate the applicability and benefits of implementing a management strategy evaluation approach to support performance assessment and adaptive management (CALM) (Research).
M	R-39. Undertake research to improve knowledge of the coastal groundwater system and its relationship to the reef system (CALM) (Geomorphology).
	R-40. Undertake contaminant sediment surveys in designated mooring and anchoring areas and at appropriate control sites, particularly in relation to hydrocarbons and antifouling paint contamination (CALM) (Sediment Quality).
	R-41. Undertake research to characterise the surficial sediments of the shallow waters (<20 m) of the reserves (CALM) (Sediment Quality).
	R-42. Undertake further research with the aim of developing cost-effective monitoring protocols to determine the 'health' of filter-feeding communities (CALM) (Filter Feeding).
	R-43. Initiate research programs to characterise the flora and fauna of representative coastal areas within the reserves in relation to determining management targets. (CALM) (Coastal biological communities)
	R-44. Continue research on the local and regional migratory patterns of whale sharks (CALM) (Whale Sharks)
	R-45. Continue biological oceanographic research to establish the relationship of spatial and temporal patterns in biophysical variables (eg temperature, nutrients, zooplankton) important to whale shark aggregation and migration. (CALM) (Whale Sharks)
	R-46. Undertake research to improve understanding of the importance of the region to whale demographics and ecology. (CALM) (Whales and Dolphins)
	R-47. Undertake research to better understand dugong population, distribution and habitat requirements in the reserves and the adjacent areas in Exmouth Gulf (CALM) and determine the current status of the dugong population in relation to historical levels. (CALM) (Dugong)
	R-48. Develop, in collaboration with the local Aboriginal community, an understanding of the significance of the area to Aboriginal people. (CALM, Coral Coast Park Council) (Indigenous heritage)
	R-49. Identify, in collaboration with the local Aboriginal community, the significance of indigenous heritage sites in the reserves. (CALM, Coral Coast Park Council) (Indigenous heritage)
	R-50. Undertake research into the history of marine animal populations in the reserves. (CALM, DoF) (Research)
L	R-51. Undertake research to investigate the morphology and growth history of the reef system and identify the importance of reef growth characteristics for the maintenance of reef biodiversity. (CALM) (Geomorphology)
	R-52. Determine the impact of built structures and their associated use, within the 40m strip, on the coastal biological communities and review the effectiveness of management strategies. (CALM) (Coastal biological communities)

Management Priority	MONITORING STRATEGIES
H-KMS	M-1. Assess the nature, level and potential impacts of human activities on shoreline intertidal reef communities within the reserves (CALM) (KMS-Intertidal reef communities) M-2. Evaluate the effectiveness of turtle monitoring programs within the reserves and implement revised/modified turtle monitoring programs as required (CALM) (KMS-Turtles) M-3. Assess the nature, level, spatial and temporal patterns and potential impacts of water sports in the reserves. (CALM) (KMS-Water sports) M-4. Continue to undertake research and monitoring of the ecological effects of recreational fishing in the reserves and review management controls as appropriate (CALM, DoF) (KMS-Recreational fishing) M-5. Implement a long-term monitoring program, commencing with baseline studies, to assess the effectiveness of the sanctuary zoning scheme. (CALM) (KMS-Monitoring)
H	M-6. Assess the nature, level and potential impact of human activities, and recreational fishing in particular, on coral communities within the reserves (CALM, DoF) (Coral reef communities) M-7. Monitor the recovery of the coral reef communities in Bills Bay every three years. (CALM) (Coral reef communities) M-8. Monitor the distribution and abundance of *Drupella cornus* in the reserves at least every three years (CALM) (Coral reef communities) M-9. Monitor shoreline communities in areas at most risk of degradation from human activities such as trampling (CALM) (Intertidal reef communities) M-10. Assess the nature, level and potential impacts of human activities on coastal biological communities within the reserves. (CALM) (Coastal biological communities) M-11. Maintain records of the incidence of by-catch of turtle species within and adjacent to the Park (CALM, DoF) (Turtles) M-12. Assess the nature, level and potential environmental impacts of commercial tourism operations within the reserves. (CALM) (Marine nature-based tourism) M-13. Monitor the abundance of selected target finfish species to assess effectiveness of management strategies, with a particular emphasis on the effectiveness of the sanctuary zones. (CALM, DoF)) (Recreational fishing) M-14. Monitor and report on recreational fishing catch/effort within the reserves (DoF, CALM) (Recreational fishing) M-15. Implement a community monitoring program for key target fish species in the Park. (CALM, DoF) (Recreational fishing)
M	M-16. Undertake a baseline litter survey in areas of historical and current high use (CALM) (Water Quality) M-17. Undertake water quality surveys at appropriate control sites and in areas of the reserves that are, or have been, exposed to contaminant inputs (CALM) (Water Quality). M-18. Monitor coral communities in areas at most risk of mooring and anchoring damage and review the effectiveness of anchoring restrictions in preventing coral damage (CALM) (Coral reef communities). M-19. Assess the nature, level and potential impacts of human activities on soft sediment communities within the reserves and review the effectiveness of existing management

Management Priority	MONITORING STRATEGIES
	strategies. (CALM, DoF) (Soft sediment communities)
	M-20. Quantify the level and significance of by-catch for recreational and commercial fishing activities in the reserves. (CALM, DoF) (Finfish)
	M-21. Monitor the behavioural response of whale sharks to nature-based activities. (CALM) (Whale Sharks)
	M-22. Monitor the behavioural response of whales to nature-based activities such as whale watching and determine the need to review existing management controls in the event of future expansion of the whale watching industry. (CALM) (Whales and Dolphins)
	M-23. Develop, in collaboration with the local Aboriginal community, protocols and a monitoring program for traditional hunting in the reserves. (CALM, Coral Coast Park Council) (Indigenous heritage)
	M-24. Develop a cost-effective monitoring strategy for maritime heritage sites within the reserves in cooperation with the maritime museum. (CALM, WAMM) (Maritime heritage)
	M-25. Assess the levels and effects of commercial fishing, particularly the marine aquarium fishery, in the reserves and review the effectiveness of existing management controls. (DoF, CALM) (Comm.fishing)
L	M-26. Monitor and report on commercial fishing catch/effort within the reserves (DoF) (Comm.fishing)

APPENDIX II: List of Abbreviations

AIMS – Australian Institute of Marine Science
CALM – Department of Conservation and Land Management
CSIRO – Australian Commonwealth Scientific and Research Organisation
DEC – Department of Environment and Conservation
DoF – Department of Fisheries
DOIR – Department of Industry and Resources
DPI – Department of Planning and Infrastructure
ECU – Edith Cowan University
JCU – James Cook University
MCMP – Marine Community Monitoring Program
MPMP – Marine Park Management Plan
MSP – Marine Science Program (DEC)
NMP – Ningaloo Marine Park
NMPMP – Ningaloo Marine Park (Long-term) Monitoring Program
NRF – Ningaloo Research Fund
NRP – Ningaloo Research Program
NWRA – North West Research Association
OSTI – Office of Science, Technology and Innovation
STCRC – Sustainable Tourism CRC
UQ – University of Queensland
UWA – University of Western Australia
WAM – Western Australian Museum
WAMSI – Western Australian Marine Science Institution
WFO – Wealth From Oceans
WWF – World Wildlife Fund

Appendix III ADDITION OF NEW PROJECTS/INFORMATION TO THE NINGALOO DATABASE

Name
Institution
Address
Phone   **Email**
Project Title
Student status (if student project)
Supervisor
Research Team (and affiliations)
Project Objectives
Management Implications (link to strategies outlined in the Management Plan for the Ningaloo Marine Park).
Project time frame – (expected start and finish dates)
Communication (publications, presentations, theses)

DEC Wildlife Licensing Requirements

Any research conducted within Marine Protected Areas and/or involving native flora and fauna requires departmental (DEC) licensing. To determine whether your research will need to be covered by a permit and to obtain the correct application form, contact:

DEC Wildlife Licensing
17 Dick Perry Ave, Technology Park,
Kensington, WA 6151

Ph: Danny Stefoni 08 9334 0439

Please return this form to Kelly Waples, Marine Science Program, DEC on fax 08 9334 0327 or email kelly.waples@dec.wa.gov.au