THE NINGALOO MARINE PARK RESEARCH AND MONITORING PLAN

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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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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 Curtin Uni.
	• 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.	
	• 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.	

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• 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.	
	• 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	

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• 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] • 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 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. Will provide the scientific basis for the long-term monitoring and management of these key ecological communities.	AIMS Curtin Uni. ECU. DoF Murdoch Uni. UWA
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

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
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 productivity. Will assist in the development of performance indicators, management targets and protection strategies to minimise disturbance from human activities.	Curtin Uni. ECU. DoF Murdoch Uni. UWA
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] • 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 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. Will provide the scientific basis for the long-term monitoring of this key ecological process..	

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
	• 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] • Undertake research to better document shark/ray movement patterns and aggregations within the reserves. (CALM, DoF). **(H)**[R-28]	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. 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.	AIMS Curtin Uni. ECU DoF Murdoch Uni. UWA
Whale sharks	• Continue research on the local and regional migratory patterns of whale sharks (CALM). **(M)**[R-44] • 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 improve understanding of whale shark ecology 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	DEH Murdoch Uni. 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

ECOLOGICAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANAGEMENT	INSTITUTIONAL INTERESTS
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]	Will identify ecologically important areas within the reserve and improve understanding of their role in maintaining key demographic processes	DEH Murdoch Uni. UWA WAM
	• Evaluate the effectiveness of turtle monitoring programs within the reserves and implement revised/modified turtle monitoring programs as required (CALM). **(H-KMS)**[M-2]	Will provide the scientific basis for the long-term monitoring of turtle population dynamics.	
	• Undertake research to determine the status and trends of the turtle populations in the reserves in relation to historical populations (CALM). **(H)**[R-30]	Will improve knowledge of turtle population status and trends and the contribution of on-reserve management to species recovery plans.	
	• Maintain records of the incidence of by-catch of turtle species within and adjacent to the Park (CALM, DoF). **(H)**[M-11]	Will improve understanding of threatening processes and the effectiveness of management responses in minimising disturbance from human activities.	
	• 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]	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.	DEH Murdoch Uni. UWA
	• 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 provide a scientific basis to recommend sustainable levels of indigenous harvest.	

'PASSIVE' SOCIAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL 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]	Will improve understanding of social and cultural dynamics of indigenous peoples and their relationship with the marine environment	DIA DEH

'PASSIVE' SOCIAL VALUES	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL INTERESTS
	• 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 inform the management of culturally significant areas	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	
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

'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]	Will improve understanding of the ecological effects of recreational fishing (ie trophic cascades) and assist in the development of appropriate management strategies	AIMS Curtin Uni. ECU DoF Murdoch Uni. UWA
	• 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 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.	
	• 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]	Will improve understanding of the effect of spatial closures on the population dynamics of targeted species.	
	• Monitor and report on recreational fishing catch/effort within the reserves (DoF, CALM). **(H)**[M-14]	Will improve understanding of the dynamics of fishing effort in response to management controls	
	• Implement a community monitoring program for key target fish species in the Park (CALM, DoF, LGA). **(H)**[M-15]	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]	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.	Curtin Uni. ECU DoF Murdoch Uni. UWA
	• Monitor and report on commercial fishing catch/effort within the reserves (DoF). **(L)**[M-26]	Will improve understanding of the dynamics of commercial fishing effort in response to management controls	

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 AIMS CSIRO Curtin Uni. ECU Murdoch Uni. UWA WAM
	• 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.	
	• 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.	

GENERIC	RESEARCH AND MONITORING STRATEGIES	RELEVANCE TO MANGEMENT	INSTITUTIONAL INTERESTS
	• 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 Quality)

Management Priority	RESEARCH STRATEGIES
H	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 existing and proposed tourism nodes identified in the Carnarvon/Ningaloo Coast Regional Strategy. (CALM) (Marine nature-based tourism)

Management Priority	RESEARCH STRATEGIES
H	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 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)

Management Priority	MONITORING STRATEGIES
	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)

Table 3: CURRENT RESEARCH DATABASE FOR THE NINGALOO MARINE PARK (draft for comment)

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
D. Alongi	AIMS - Ph: (07) 4753 4313. Fax: (07) 4772 5852. Email: d.alongi@aims.gov.au	Mangrove growth patterns in the gulf of Ningaloo	N/A	N/A	On going	
S. Armstrong	University of Queensland - c/o Gordon Campbell, g.campbell@uq.edu.au Ph:+61 7 3365 2991 Fax: +61 7 3365 7261	A new method for estimating *Drupella* sp. density in Ningaloo Marine Park	Honours	Peter Harrison, University of Qld and Chris Simpson, CALM	Started 2004 - finishing 2005	
R. Bailye	Peter Mack Turtle Conservation Program	Turtle egg and hatchling handling and monitoring *and* turtle nest protection and monitoring	N/A	N/A	On going	
E. Bonsall	Murdoch University - c/o Mike van Keulen 9360 2369 keulen@murdoch.edu.au	Seagrasses and benthic productivity at Ningaloo (yet to be finalised)	possible PhD	Mike van Keulen, Murdoch and Marion Cambridge, UWA	Starting 2005	
I. Burghardt	European University	Foraminiferans in sediment in Ningaloo				
J. Carlton	AIMS - j.carlton@aims.gov.au	Macro zooplankton and systems productivity in relation to whale sharks	N/A	N/A	On going	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
R. Carter	Murdoch University - Centre for Fish and Fisheries Research - c/o Lynnath Beckley, lbeckley@essun1.murdoch.edu.au	Environmental factors influencing green turtle nesting at North West Cape and Ningaloo	Masters	Lynnath Beckley, Murdoch	Started July 2004, finishing June 2005	
L. Cassata	Curtin University - Department of Applied Geology - lauracassata@katamail.com 0419 748 240	Substrate mapping of sanctuary zones using GIS in Ningaloo Marine Park	Post doc research	Lyndsay Collins, Curtin	Finish date Dec 04 (draft submitted)	
L. Cassata	Curtin University - Department of Applied Geology - lauracassata@katamail.com 0419 748 240	Coral reef communties, habitat and substrate in and near sanctuary zones in Ningaloo Marine Park	Post doc research	N/A	In progress	
J. Catlin	Curtin University - Department of Humanities. Ph: 0415 488 975 email: jfc05@yahoo.com.au	Topic: Visitor satisfaction of swimming with whale sharks at Ningaloo	Honours	Ray Jones and David Wood	Started Feb 2005, finishing Oct 2005	
L. Collins	Curtin University/CRC Sustainable Tourism - L.Collins@curtin.edu.au 9266 7968	Climate change and coastal zone management of Carnarvon and Ningaloo coast	Staff Research & P/Grad Students	N/A	On going	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
L. Collins	Curtin University/CRC Sustainable Tourism - L.Collins@curtin.edu.au 9266 7968	Geological evolution of Ningaloo reef	Staff Research & P/Grad Students	Lindsay Collins Curtin	On going	
L. Collins & Others	Curtin University - Department of Applied Geology - L.Collins@curtin.edu.au, Ph: 9266 7968	Ningaloo Coastal Management Project	Staff Research & P/Grad Students	Lindsay Collins, Curtin	Ongoing	
L. Collins & Others	Curtin University - Department of Applied Geology - L.Collins@curtin.edu.au, Ph: 9266 7968	Continental Shelf Sediments & Coral Reef of the Northeast Shelf	Staff Research & P/Grad Students	Lindsay Collins, Curtin	Started 2000 & Ongoing	
L. Collins, F. Read, et al	Curtin University - Department of Applied Geology - L.Collins@curtin.edu.au, Ph: 9266 7968, & Virginia Polytechnic Institute and State University	Evolution and Climate History of the Limestone of the Cape Range	University Research	N/A	Ongoing	
T. H. Cribb	Queensland University - T.Cribb@mailbox.uq.edu.au	A study of helminth parasites on fish	N/A	N/A	On going	
X. Deng	Curtin University Western Australian Centre for Geodesy- W.Featherstone@cu	Improvement of geodetic paprameter estimation in coastal regions from satellite radar altimetry	PhD	W. E. Featherstone	1999 - 2002	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
	rtin.edu.au phone 08 9266 2734 fax 08 9266 2703					
P.J. Doherty and J. McIlwain	AIMS - p.doherty@aims.gov .au	Monitoring the replenishment of fish populations at Ningaloo reef	N/A	N/A	On going	
W. E. Featherstone	Curtin University Western Australian Centre for Geodesy- W.Featherstone@cu rtin.edu.au phone 08 9266 2734 fax 08 9266 2703	Prediction of sea level change around Australia and its calibration and validation by satellite-geodetic measurements	N/A	N/A	2003 - 2007	
M. Furnas	AIMS - m.furnas@aims.gov. au	Phytoplankton and microbial productivity and nutrient cycling in the North West Shelf, Murion and Exmouth Gulf	N/A	N/A	On going	
S. Gardner	University of WA - gardns03@segs.uw a.edu.au Ph: +61 8 6488 3644 Fax: +61 8 6488 1037	The Ningaloo reef marine environment: Ecology of manta rays (*Manta birostris*) in the context of human interactions	PhD	Brenton Knott, UWA, Ian Elliot, UWA and Mark Meekan, AIMS	Finishing 2007	
R. Gianotti	University of Western Australia - c/o Anya Waite, waite@cwr.uwa.edu .au Ph: +61 8 6488	Vulnerability of Ningaloo Reef to pollution	PhD	Anya Waite, UWA	Started 2003	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
	3082 Fax: +61 8 6488 1015					
A. Griffiths	University of Western Australia - agrif@yorku.ca	Ningaloo reef area management	PhD	Trevor Ward, UWA	Started Feb 2004	
C. Hahesy	Curtin University - c/o Lindsay Collins, L.Collins@curtin.edu.au	Geomorphology and coastal management of the Cape Range region	Honours	Lindsay Collins, Curtin	Started Jan 2004 - finishing end of 2004	
A. Heyward and L. Smith	AIMS - a.heyward@aims.gov.au	Reef coral population dynamics & annual recruitment processes of spawning coral	N/A	N/A	On going	
B. Hutchins	WA Museum - Barry.Hutchins@museum.wa.gov.au	Checklist of fishes of Ningaloo reef	N/A	N/A	Ongoing, expected to finish 2006	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
T. R. Irvine	Murdoch University - tennille_irvine@hotmail.com	Collection of coral specimens for research to quantify metabolic consequences of reproduction in zooxanthellate scleractinian corals at Ningaloo reef and assess their vulnerability to stress during the reproductive period.	PhD	Mike van Keulen and Mike Borowitzka, Murdoch, John Keesing, CSIRO and Andrew Heyward, AIMS	Started 2004	
C&M. Jenner	Centre for Whale Research - Ph: 360-378-5835 Fax: 360-378-5954	Spatial and temporal distribution of humpbacks and blue whales off the North West Cape	N/A	N/A	On going	
M. Johnson	University of Western Australia - msj@cyllene.uwa.edu.au Ph:6488 2244 Fax: 6488 1029	Study genetic structure, demography & recruitment of several species of marine invertebrates.	N/A	N/A	On going	
A. Kingham	Curtin University/ Remote Research - compton@iinet.net.au 0415 529 550 9310 3425	Sustainability of the wilderness experience: a case study in environmental stewardship for campers on WA's Ningaloo reef	PhD	Roy Jones, David Wood, Jack Carlsen, Alan Pilgrin, Curtin and Nick D'Adamo, CALM	Started 2005 - 2010	
S. Lee	Curtin University - Sam.Lee@curtin.edu.au Tel: 08-9266-3421 Fax: 08-9266-	Hydrogeology of the Ningaloo reef region	PhD	Lindsay Collins and A. Rathur, Curtin	Started Jul 02 - finishing 2006	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
	3153					
C. Lovelock	University of Queensland - c.lovelock@uq.edu.au Ph: 3365 2304 Fax: 3365 4755	Effects of nutrient enrichment on mangroves in Ningaloo	N/A	N/A	On going	
C. Lovelock	University of Queensland - c.lovelock@uq.edu.au Ph: 3365 2304 Fax: 3365 4755	Assessing linkages across arid zone estuarine landscapes in the Gulf	N/A	C. Lovelock, University of Queensland, Ilka Feller, Smithsonian, USA , Samantha Joye, University of Georgia, USA and Helen Penrose, Ocean Wise, Exmouth	Starting 2005	
F. Macgregor	Murdoch/ Independent - c/o Mike van keulen, keulen@murdoch.edu.au 9360 2369	Pilot study: Feeding ecology in manta rays	possible PhD	Mike van keulen, Murdoch	Ongoing	
O. Makarynskyy	Curtin University Western Australian Centre for Geodesy-O.Makarynskyy@curtin.edu.au phone 08 9266 7398 fax 08 9266 2703	Neural forecasts of sea level at the Baseline Sea Level Monitoring Project sites in Western Australia	N/A	N/A	2004	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
D. McKinnon	AIMS - d.mckinnon@aims.gov.au	Productivity of pelagic ecosystems off the North West Shelf, Murion and Exmouth Gulf	N/A	N/A	On going	
R. McCauley	Curtin University - r.mccauley@cmst.curtin.edu.au	Assessing the effect of marine seismic surveys on marine animals such as whales and fish	N/A	N/A	On going	
R. McCulloch	MG Kailis Group	Abalone research	N/A	N/A	On going	
S. McKinna-Jones	James Cook University - pjsmj2@bigpond.com	Clutch survivorship in turtles nests	Grad. Dip.	Emma Gyuris, JCU	Started 2004, finishing 2004	
M. Meekan	AIMS, Darwin - m.meekan@aims.gov.au	Demography analysis of reef fishes	N/A	N/A	On going	
M. Meekan	AIMS, Darwin - m.meekan@aims.gov.au	Whale sharks, migration and ecology	N/A	N/A	Almost complete	
A. P. Negri	AIMS - a.negri@aims.gov.au	Study toxicity in crustaceans & molluscs	N/A	N/A	On going	
J. Parker	University of Western Australia - jparker@geol.uwa.edu.au	To document the benthic foraminiferal populations that inhabit the Ningaloo reef and look at spatial variations and their significance.	PhD	David Hauge, A. George, B. Griffiths and K. H. Wyrwoll, UWA	Started 1998 - present	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
J. Pandolfi and B. Greenstein	University of Queensland	Range shifts in coral: evidence from the fossil record	N/A	N/A	On going	
K. Pendoley	Murdoch University - pendoley@newton.dialix.com.au Ph: 9316-8818	Sea turtles and environmental management of industrial activities on the North West Shelf, Western Australia	PhD	Stuart Bradley, Murdoch	Finishing 2004	
C. Lovelock and H. Penrose	Ocean Wise /University of Queensland - c.lovelock@uq.edu.au Ph:33652304 Fax: 3365 4755	Links between terrestrial and nearshore environments in terms of nutrients, Exmouth Gulf (megafauna surveys)	N/A	N/A	On going	
J. Polovina	NOAA - Jeffrey.Polovina@noaa.gov Ph:(202) 482-6090 Fax: (202) 482-3154	Whale shark research	N/A	N/A	On going	
P. Pursell	Murdoch University, Asia Research Centre - P.Pursell@murdoch.edu.au 9360 6479	Economic, ecological and cultural patterns and links between humans and the whale shark (Rhincodon typus)	PhD	James Warren, Murdoch	Started 2003	
M. Press	Charles Darwin University	Photo identification of whales sharks at Ningaloo	Masters	Mark Meekan, AIMS	Started 2003 - finishing 2004	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
A. Richards	Joint venture including CALM & WWF.	Ningaloo community turtle monitoring program\	N/A	N/A	On going	
N. Rosser	Murdoch University - 30151469@student.murdoch.edu.au 0438 671 661	Investiagting the incidence of bi-annual spawning on two coral reefs off orth Western Australia	Honours	Mike van keulen, Murdoch and Luke Smith, AIMS	Started Aug 2004 , finishing Aug 2005	
M. Ruchel	Greenpeace Australia - Matt.Ruchel@au.greenpeace.au 03 9478 9769, 0408837138	Study the effects of water temperature on coral reef structure	N/A	N/A	On going	
A. Ryans-Taylor	Murdoch University - 19909965@student.murdoch.edu.au	Conservation and social change: how conservation of the Ningaloo coast engenders social change within the community	Honours	Laura Stocker and Steve Kinnane, Murdoch	Finish date: 20th December, 2004	
L. M. B. Schaffelke, D. Klumpp and D. McKinnon	AIMS	Seagrasses and seaweeds (macroalgae) of Exmouth Gulf: their distribution and importance in primary production	N/A	N/A	On going	
G. Shiell	University of Western Australia	Aspects of the ecology of H. nobilis, a sea cucumber of significant commercial value	PhD	Brenton Knott, UWA	Started 2000, finishing 2005	
J. Sleeman	Charles Darwin University, AIMS	Modelling whale shark distributions on Ningaloo reef with remote sensing and GIS	PhD	Mark Meekan, AIMS	Started end 2004 to finish mid 2007	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
L. Smith	AIMS - l.smith@aims.gov.au	Population dynamics of coral at Ningaloo: a longterm coral reef status assessment	N/A	N/A	On going	
Steinberg et al	AIMS - c.steinberg@aims.gov.au	A study of long term variability in regional currents, monitoring the Leeuwin Current off the NW shelf	N/A	N/A	On going	
C. Steinberg	AIMS - c.steinber@aims.gov.au	Ningaloo physical oceanography: temperature, current, tide and wave investigations	N/A	N/A	On going	
J. Stevens	CSIRO, Tasmania - john.d.stevens@csiro.au. (03) 6232 5353	Movements and behaviour of whale sharks	N/A	N/A	On going	
G. Taylor	Independent researcher/ collaboration with AIMS	Study of whale sharks including non-invasive morphometric measurements	N/A	N/A	On going	
E. Twiggs	Curtin University - Department of Applied Geology - L.Collins@curtin.edu.au, Ph: 9266 7968	Morphology and Habitats of Ningaloo Reef	PhD	Lindsay Collins	Starting 2005	
D. A. Waayers	Murdoch University - dwaayers@essun1.murdoch.edu.au Ph: +61 8 9360 6391, Mobile: 04004884 34	PhD study of marine turtles, developing a management framework for sustainable tourism	PhD	David Newsome, Dianne Lee, Murdoch	Started Nov 2001, finishing April 2005	

CURRENT RESEARCH DATABASE FOR NINGALOO

Researcher	Institution and Contact details	Project title	Study type	Supervisor (if an academic study)	Status	Additional comments
A. M. Waite	University of Western Australia - waite@cwr.uwa.edu .au Ph: +61 8 6488 3082 Fax: +61 8 6488 1015	Assessing the vulnerability of Ningaloo Marine Park to marine pollution.	N/A	N/A	On going	
Waite, et al	University of Western Australia - waite@cwr.uwa.edu .au Ph: +61 8 6488 3082 Fax: +61 8 6488 1015	The biological oceanography of Ningaloo reef: coastal plankton as a food source for the reef	N/A	N/A	On going	
A. Waite, G. Ivey and C. Oldham	University of Western Australia - waite@cwr.uwa.edu .au Ph: +61 8 6488 3082 Fax: +61 8 6488 1015	Interactive coastal oceanography including linkages with the Cape Range caves	N/A	N/A	On going	
F. Webster	Murdoch University - 30300414@student. murdoch.edu.au	An investigation into the effect of fish predators, urchin densities and algal cover on coral recruitment	PhD	Mike van Keulen, Murdoch, Russ Babcock, CSIRO and Luke Smith, AIMS	Started 2004	
M. Woo	University of Western Australia - woo@cwr.uwa.edu. au Tel: (+61 8) 9380 1686 Fax: (+61 8) 9380 1015	Continental shelf processes between Shark Bay and North West Cape	PhD	Chari Pattratchi, Curtin	Started 1999 - to present	

CURRENT RESEARCH DATABASE FOR NINGALOO						
Researcher	**Institution and Contact details**	**Project title**	**Study type**	**Supervisor (if an academic study)**	**Status**	**Additional comments**
J. Carlsen and D. Wood	Curtin University/CRC for Sustainable Tourism - D.Wood@curtin.edu.au phone: (08) 9266 3334 / 7353 fax: (08) 8266 3818	Assessment of the Economic Value of recreation and Tourism in Western Australia's National Parks, Marine Parks and Forests	N/A	N/A	Completed	
D. Wood	Curtin University/CRC for Sustainable Tourism - D.Wood@curtin.edu.au phone: (08) 9266 3334 / 7353 fax: (08) 8266 3818	Valuing nature area tourism in Ningaloo	N/A	N/A	On going	

RESEARCH PROGRAM FOR THE NINGALOO COAST

The State government has committed an additional $5 million over 4 years to a research program that will help protect the Ningaloo Coast

Why the Research Program Was Developed

The Ningaloo Coast and the Cape Range Peninsula contain some of the world's great natural wonders.

The magnificent coral reef, rugged landscapes, beautiful beaches, open and remote character and extensive range of animal life that includes the famous whale shark and the most diverse concentration of subterranean fauna in the world, are some of the reasons why the Government believes this region should be listed as a World Heritage site.

The natural wonders of the region are important not only in themselves, but because of the potential they have to promote eco-tourism. It is estimated that $127 million a year of tourist expenditure is directly attributable to the Ningaloo Marine Park and Cape Range National Park, and this is expected to increase as more people visit the region.

Unless it is carefully managed, increasing visitation and expansion of a range of recreational and commercial uses of the Ningaloo area could threaten its natural heritage values and diminish its capacity to continue to grow as a national and international tourist destination.

A framework for good management is being established through measures such as the expansion of the Ningaloo Marine Park and the use of strong planning controls to prevent inappropriate development. This research package is another important component of the Government's strategy for the protection and sustainable development of the Ningaloo Coast.

Objectives of the Research Program

The Ningaloo Coast Research Program aims to:

- Underpin protection and management of the Ningaloo Coast by providing a good understanding of the conservation needs of the area, and how those needs can best be met;
- Support the World Heritage nomination of the Ningaloo Marine Park and North West Cape; and
- Boost efforts to conserve threatened species, including the whale shark.

An outline of the research program, which will be refined in response to stakeholder comment, is set out overleaf.

How the Research Program was developed

The Premier's Office of Science and Innovation developed the research program, in consultation with the Department of Conservation and Land Management, Department of Fisheries, Department of Environment, WA Museum, Department of Industry and Resources, CSIRO, the Australian Institute of Marine Science (AIMS) and the Gascoyne Development Commission.

Delivery of the Research Program

The research program will funded with an allocation of $5 million over 4 years, drawn from the Government's Innovate WA 2 fund.

The research program will be delivered through the Strategic Research Fund for the Marine Environment (SRFME), a cross-government group chaired by Western Australia's Chief Scientist.

In order to obtain maximum value for the State Government's investment, SRFME will work with Commonwealth agencies, the universities and others to identify opportunities for jointly-funded projects,

In relation to the whale shark initiative, there is potential to work with not only the Commonwealth Government, but with conservation organizations such as WWF which are participating in conservation and research efforts taking place overseas. Local communities and eco-tourism operators will also be involved where possible in the delivery of research programs.

Key Components of the Research Program

The key components of the Research Program for the Ningaloo Coast are as follows:

- Iconic megafauna A key part of the eco-tourism experience at Ningaloo centers on large iconic species such as whale sharks, manta rays and turtles, and the conservation needs of these species need to be well understood. While the whale shark is protected in Australian waters, the species is highly migratory and are exploited as food in several countries in South Asia and Southeast Asia. Recent research by the CSIRO and the Australian Institute of Marine Science has shown that some of the whale sharks that visit Ningaloo migrate north to these countries. Relatively little is known of the migratory patterns of whale sharks and why they visit Ningaloo, and a key component of research needs to address this important knowledge gap through tagging and other techniques. It is proposed that this research be undertaken of an international program involving other countries in the region. As a first step, efforts will be made to attract an international conference or workshop to WA to develop a program of international cooperative research.

- Biodiversity inventories and assessments to adequately describe the biodiversity of the region, including natural levels of variability (eg. seasonal, interannual) in key facets of the biology and ecology of the reef system. These need to be ascertained through research and monitoring programs at key representative locations; this would enable current and projected environmental changes caused by human activities (e.g. anchoring, diving, nutrient inputs and coastal development) to be assessed within the context of how the ecosystems behave naturally. This work would need to extend to assessment of the unique groundwater fauna underlying the Cape Range coastal plains.

- Improved understanding of the biological oceanographic characteristics of the reef. These underpin the viability of key iconic marine species, such as turtles, whale sharks, corals, dugong and manta rays. For example, it is thought that the introduction of nutrients from deep ocean waters 'upwell' against the shallow reef and drive the growth of microscopic and, in turn, larger plants and animals. The southward flow of the warm tropical waters of the Leeuwin Current then acts as a hydraulic conveyor belt, transporting waterborne plants, eggs, larvae and mature animals southward along and into Ningaloo. The highly predictable coral spawning period, and associated whale shark and manta ray aggregations, highlight the seasonality of the reef. Identification of these ecologically important or sensitive times of the year allow special precautions to be put in place on a seasonal basis to target the protection of key elements of the Ningaloo reef system.

- The physical environment (water circulation patterns and onshore/offshore transport) needs to be examined in order to be able to understand how eggs and larvae replenish floral and faunal populations as they disperse and settle throughout the park and beyond after spawning. This is important given the regular occurrence of natural and/or human induced coral mortality (such as from coral bleaching, carnivorous snails and starfish). Similarly, an understanding of the physical dynamics means being able to predict where contaminants that enter the environment will be transported and in what concentrations, thus permitting prediction of their ecological effects on plants and animals. Furthermore, this work will help us understand connectivity along the coast, such as the extent to which Ningaloo is a source of propagules to sustain important 'downstream' ecosystems such as Shark Bay and the Abrolhos Islands.

- An assessment of the increased tourism impact on recreational and commercially fished species needs to be undertaken, as well as building an understanding of the natural and anthropogenic changes which will affect fish stocks: information that is essential to the ecologically sustainable management of these aquatic resources. Specifically an up-to-date survey of the effort and catch of recreational fishers is needed together with an assessment of what levels of recreational fishing can be sustained and what impact these have on the non-target fish and other components of the ecosystem such as algae, corals and other invertebrates.

- Protection of Biodiversity at Ningaloo requires a dedicated scientific approach to evaluating the effectiveness of management options both in relation to size and location of no take areas and other zones of less stringent protection, as well as assessment of the best modes of management within each type of zoning. This research will assist the process of Performance Assessment outlined in the Ningaloo Marine Park Draft Management Plan.

Research on the value of no take areas in the Ningaloo Marine Park (i.e. locally specific) to both conservation and fishing amenity objectives is also needed. The research will involve some habitat mapping and will include some targeted projects on understanding specific threats to coral biodiversity such as posed by the marine snail Drupella. Assessing the suitability of a number of indicators of "reef health" such as coral recruitment will also be carried out.

- Local significance of global threats. A specific program of research to determine impact and risk of direct threats to the coral reef itself is needed. The global warming consequences of greenhouse gases mean coral reefs are being threatened by rising water temperatures, which increase the frequency of coral bleaching events causing high mortality of corals. Increases in the acidity of seawater as the ocean absorbs more carbon dioxide from the atmosphere make it difficult for corals to build new skeletons. Global warming and sea level rise may also have an impact on Ningaloo, which needs to be assessed.

- The development of computer based management tools using models, which evaluate different management strategies, assess risk and predict the consequences of environmental change. These enable natural resource managers to run current and projected scenarios which link human pressures and natural environmental response, thereby enabling management strategies to be designed and implemented to maximise the multiple use potential of an area while protecting key environmental values and managing risks from any key threatening processes. Importantly, such models should take into account episodic, but acute events such as cyclones and outbreaks of corallivorous snails and starfish as well as terrestrial impacts from fresh water runoff following heavy rainfall, again usually associated with tropical storms.