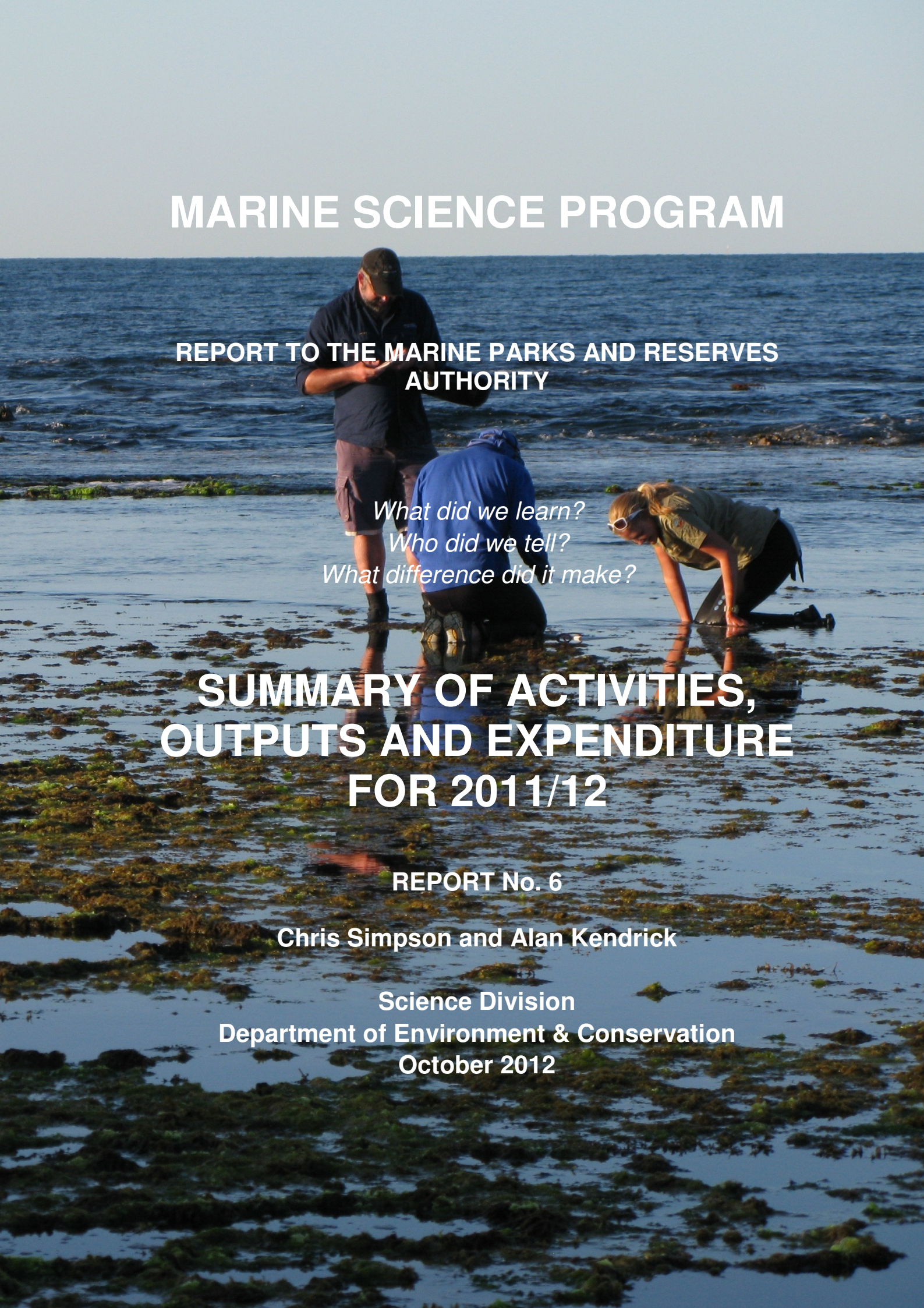
MARINE SCIENCE PROGRAM



REPORT TO THE MARINE PARKS AND RESERVES AUTHORITY

What did we learn?
Who did we tell?
What difference did it make?

SUMMARY OF ACTIVITIES, OUTPUTS AND EXPENDITURE FOR 2011/12

REPORT No. 6

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Science Division
Department of Environment & Conservation
October 2012

Cover photo: Staff from DEC's Marine Science Program and Swan Coastal District undertaking intertidal reef surveys in the Marmion Marine Park (Photo: John Huisman).

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Summary

This report summarises the performance of the Marine Science Program (MSP) for the 2011/12 financial year and is part of the Department of Environment and Conservation's (DEC) reporting and accountability obligations, under the CALM Act, to the Marine Parks and Reserves Authority (MPRA). This report is based on the implementation of the *MSP Business Plan: 1 July 2011 – 30 June 2012*.

Expenditure on marine science (i.e. research and monitoring) in DEC occurs in the MSP, and in regional and specialist branch cost centres. This report focuses primarily on MSP expenditure and outputs for 2010/11, although some expenditure on marine science by regions and specialist branches is included. 'In kind' contributions from collaborating external agencies are not included.

The report format includes summaries of progress during 2011/12 on individual marine science projects. The project summaries are also reported in the Science Division's 2011/12 Annual Research Activity Report, and a similar format is also employed to outline annual progress on marine science projects currently being undertaken by other DEC Divisions. The report also includes MSP collaborations and 2011/12 expenditure. Details of the 2012/13 MSP budget and projects are provided, including a detailed work plan for the Western Australian Marine Monitoring Program (WAMMP). The final section of the report is a bibliography of all publications, reports and presentations made by MSP staff during 2011/12.

The MSP has continued to grow in capacity with 25 staff working as full-time or part-time in the Program during 2011/12. Several of these positions are shared with other DEC branches, such as Geographic Information Services and the WA Herbarium. The MSP monitoring and temperate and tropical research groups have continued to develop their programs in accordance with strategic plans, and the progressive implementation of WAMMP continues to increase the quantitative asset condition-pressure-response data included in the MPRA audit process for all DEC-managed marine parks and reserves. Research conducted by MSP contributes to this process by undertaking quantitative baseline studies of ecological assets in marine reserves, and working to develop indicators and protocols for long-term monitoring.

The first phase of a major externally-funded research and monitoring project examining the impacts of dredging and spoil dumping by the Gorgon Gas Project on the biodiversity of the Barrow/Montebello Islands marine protected areas is now moving towards completion with the final summary report due by mid-2013. The second phase will continue coral and fish communities at a lower frequency and at fewer sites to assess potential longer-term impacts. Similarly, MSP's role of administration, co-ordination and integration of WAMSI-1 Node 3, the Ningaloo Research Program, is now completed with a final summary report completed in early 2012. The WAMSI focus now moves to planning and implementation of the Kimberley Marine Research Program, which is due to begin in late 2012.

1. Introduction

This Report No. 6 outlines the performance of the Marine Science Program (MSP) for the 2011/12 financial year and is part of the Department of Environment and Conservation's (DEC) reporting and accountability obligations, under the CALM Act, to the Marine Parks and Reserves Authority (MPRA). Copies of this report will also be provided to the Director General, the Deputy Director General Parks and Conservation, Divisional Directors and all Regional, District and Specialist Branch Managers.

Established in 2007 with only four members, MSP now has with ten permanent and a similar number of contract staff. MSP now supports integrated teams focussed on tropical and temperate research, state-wide marine monitoring, evaluation and reporting, and marine fauna. During 2011/12, externally funded staff worked on:

- investigating the impacts of dredging and spoil dumping associated with the Gorgon Project on the biodiversity of the Barrow/Montebello Islands marine protected areas.
- the North West Shelf flatback turtle conservation program.
- a review of historical data relevant to the management of the proposed Dampier Archipelago marine protected areas.

Also of significance to the Marine Science Program during 2011-12 was the development and implementation of DEC's Policy Statement No. 78 *Science Policy* and the creation of new CALM Act marine protected areas in the Leeuwin-Naturaliste region and at Camden Sound.

Expenditure on marine science (i.e. research and monitoring) primarily occurs in the MSP, which is positioned within DEC's Science Division and this report focuses primarily on expenditure and outputs for 2011/12 by MSP. However, marine science projects are also managed by staff in other DEC Divisions, and this report also provides progress reports on marine science projects managed by staff in the Divisions of Regional Services, Nature Conservation and Parks and Visitor Services.

This report includes summaries of progress made during 2011/12 on individual marine science projects. These summaries are also reported in Science Division's Annual Research Activity Report, and the same format is used to report on progress on marine science projects currently being managed by other DEC Divisions.

The report also includes MSP collaborations and details of 2011/12 expenditure. Details of the 2012/13 MSP budget and projects are also provided, as is a detailed work plan for the Western Australian Marine Monitoring Program (WAMMP). The final section of the report is a bibliography of all publications, reports and presentations made by MSP staff during 2011/12.

2. MSP staff during 2011/12

Dr Chris Simpson	Program Leader
Dr Kelly Waples	Principle Research Scientist (WAMSI Science Coordinator)
Dr Kim Friedman	Principle Research Scientist (Monitoring)
Dr Scott Whiting	Principle Research Scientist (Gorgon sea turtle project)
Dr Shaun Wilson	Senior Research Scientist (Tropical)
Dr Alan Kendrick	Senior Research Scientist (Temperate)
Dr Stuart Field	Senior Research Scientist (Gorgon dredge project)
Dr Bob Prince	Senior Research Scientist (Sea turtles)
Dr Mike Rule	Research Scientist (Temperate)
Dr Tom Holmes	Research Scientist (Tropical)
Dr Richard Evans	Research Scientist (Gorgon dredge project)
Dr Holly Raudino	Research Scientist (Gorgon sea turtle project) (*from February 2012*)
Dr Conrad Speed	Research Scientist (Tropical) (*from May 2012*)
Dr John Huisman	Phycologist (*part-time in MSP*)
George Shedrawi	Research Scientist (Monitoring)
James Moore	Research Scientist (Gorgon dredge project)
Kevin Crane	Research Scientist (Gorgon sea turtle project) (*from April to June 2012*)
Kevin Bancroft	Research Scientist (Monitoring)
Shelby Noble	Research Scientist (Temperate) (*from March 2012*)
Florian Mayer	Research Scientist
Chris Nutt	Research Scientist (Dampier Archipelago review) (*from February 2012*)
Kathy Murray	Research Officer (Remote sensing) (*part-time in MSP*)
Bart Huntley	Research Officer (Remote sensing) (*part-time in MSP*)
Corrine Severin	Technical Officer (*August-September 2011 and from March 2012*)
Ryan Douglas	Technical Officer

3. Report on MSP projects during 2011/12

Major MSP projects, activities and outputs for 2011/12 are outlined below. The project summaries are based on the MSP component of Science Division's Annual Research Activity Report.

WAMSI 1 Node 3: Science administration, coordination and integration

CF 2011-116

Team members

C Simpson, K Waples

Context

In 2005, the State Government allocated $5 million to undertake research at Ningaloo Marine Park that would underpin its management. A research plan was developed to address key strategies in the Ningaloo Marine Park Management Plan. In 2007 a joint research body, the Western Australian Marine Science Institution (WAMSI) was formed. DEC is the leader of Node 3 of WAMSI, which addresses research in marine biodiversity and conservation. At the same time as the development of WAMSI, CSIRO Wealth from Oceans National Research Flagship program established the Ningaloo Collaboration Cluster (the Cluster) to address the integration of knowledge of reef use, biodiversity and socio-economics into a Management Strategy Evaluation (MSE) model for Ningaloo Marine Park and the Gascoyne region in general. The research program of the Cluster complements that undertaken through WAMSI and collectively these two programs, along with core research undertaken by the Australian Institute of Marine Science (AIMS) at Ningaloo, have become known as the Ningaloo Research Program (NRP). DEC is working together with representatives from the Cluster and AIMS to ensure the research program will meet management needs and be properly integrated and communicated to those who will use it.

The science plan for Node 3 of WAMSI consists of six main projects led by a different institution. Thus the coordination and administration role entails ensuring that all project plans are functioning according to the agreed outputs and timeframes. A key focus of this project is to ensure the transfer and uptake of knowledge generated through the research into DEC management policies, practices and actions. The latter element will become an increasing focus of this project as the research program progresses to completion in 2010 and the final synthesis report is developed for the wrap up of WAMSI in December 2011. As such, both communication and data management are critical elements in knowledge transfer and uptake and are being addressed through this program.

Aims

- Ensure the coordination and administration of the research program.
- Ensure the integration of this research program with other research within WAMSI and with external programs relevant to the Ningaloo Marine Park.
- Ensure the outputs of research undertaken through the NRP reach target audiences.
- Ensure that knowledge transfer and uptake occurs between scientists, resource managers and decision-makers.
- Ensure the long-term storage and custodianship of data from the research undertaken.

Summary of progress and main findings

- The Node 3 Final Summary Report was completed and submitted to WAMSI.
- Metadata for all WAMSI Node 3 projects provided to WAMSI Data Management Officer and available on Metadata Entry and Search Tool.

- Final reports have been submitted and approved by WAMSI for all but two of the research projects within Node 3.
- Joint communication activities have been coordinated with the Ningaloo Collaboration Cluster and AIMS.
- A report outlining the Western Australian State Government marine research priorities was developed and provided to the WAMSI Strategic Programs Committee for inclusion in the WAMSI Marine Research Institutes proposal to Government for WAMSI 2.

Management implications

- A key role of this project is to ensure that outcomes of the research both within the NRP and from external research programs are reviewed and used in refining and updating management of the Ningaloo Marine Park through changes to policy, management activities and planning exercises where relevant. Specific implications for management will come from each of the individual projects in the research program and will be implemented as appropriate over time.
- The development of a knowledge transfer and uptake framework will be instrumental in ensuring a similar process is followed for other research projects conducted by DEC.

Future directions (next 12 to 18 months)

- Ensure the findings and information from the Ningaloo research is disseminated to all relevant DEC users.
- Progress knowledge transfer to ensure that research findings are available and useful to relevant managers.
- Submit a paper for publication in a peer-reviewed journal on the knowledge transfer framework and process.

WAMSI 2: Kimberley Marine Research Program

CF 2011-117

Team members

C Simpson, K Waples

Context

In June 2011, the Western Australian Government released the Kimberley Science and Conservation Strategy (KSCS), with its overarching aim to recognize and conserve one of the world's last great wilderness areas. The Kimberley Marine Research Program (KMRP) will undertake a program of marine research to support the management of the proposed state marine parks at Camden Sound, North Kimberley, Roebuck Bay and Eighty Mile Beach and the coastal waters outside these proposed marine parks. The KMRP will be developed and implemented through the Western Australian Marine Science Institution (WAMSI), with DEC as lead agency responsible for the direction, coordination and administration of the research program.

The KMRP Science Plan was developed and approved by the WAMSI Board in late 2011 to address information gaps needed to support the management of the coastal waters of the Kimberley region. The plan comprises a suite of research projects focussed around two themes:

- bio-physical and social characterisation that aims to provide the foundational datasets required for marine park and marine resource management, as well as better understanding and management of current human impacts; and
- understanding key ecosystem processes that aims to provide the scientific understanding of ecosystem functioning and response to a range of potential human impacts that are likely to arise in the future, including climate change.

Aims

- Ensure the KMRP research projects are developed in line with state priority needs, and will meet DEC management strategies for the newly-formed and proposed Marine Protected areas in the Kimberley.
- Ensure integration of research projects within the KMRP both in terms of field logistics and science findings.
- Ensure the outputs of the research undertaken through the KMRP reach target audiences.
- Ensure that knowledge transfer and uptake occurs between scientists, resource managers and decision-makers.

Summary of progress and main findings

- Publication of the Kimberley Marine Research Program Strategy outlining the general directions and process to develop the KMRP.
- Publication of the Kimberley Marine Research Program Science Plan outlining the key research areas and management questions that will be addressed.
- Development and review of 25 Science Concept Plans to be considered as part of the KMRP with advice provided to WAMSI.

Management implications

Research will increase capacity to manage human impacts on the Kimberley Marine Parks and improve understanding of the ecological significance of the biodiversity assets of the Kimberley.

Future directions (next 12 to 18 months)

- Development of the full suite of Science Project Plans that will comprise the KRMP.
- Initiation of early start research projects in the Kimberley.
- Communication activities to promote the KMRP science plan and suite of research to relevant marine resource managers as well as to local and Indigenous communities in the Kimberley.

Conservation of marine turtles in Western Australia

SPP 1993-040

Team members

B Prince

Context

All marine turtles found in Western Australian waters are listed as threatened species by the Commonwealth of Australia and the state of Western Australia. Currently, turtle research and monitoring in Western Australia is undertaken by DEC Science Division and regional staff, academics and industry consultants, with limited standardisation of methods or integration of data. There has also been a significant increase in turtle research in Western Australia by external scientists as a result of the potential impacts on these species from industrial development. A comprehensive review of all (internal and external) historical and current turtle research and monitoring is needed to underpin the development of an integrated state-wide approach to turtle research and monitoring in Western Australia.

Aims

- Provide critical scientific information for the conservation of marine turtles in Western Australia and the management of human pressures on these animals.

- Gain an adequate understanding of the distribution and abundance of marine turtle populations utilising Western Australian rookeries and marine habitats, the nature of inter-relationships within groups using different rookeries, and the linkages between nesting and living areas important for the maintenance of these adult turtle populations.
- Develop an understanding of the processes affecting the maintenance and abundance of these marine turtle populations as an aid to addressing management needs.
- Develop appropriate management measures and interpretation packages.

Summary of progress and main findings

- Paper on olive ridley turtle occurrence in Western Australia published in *Marine Turtle Newsletter*.
- Paper on Catch–Mark–Recapture (C–M–R) data for hawksbill turtles nesting on Varanus Island published in *Marine Biology*.
- Paper on historical time-series data from the Exmouth Gulf fishers collaboration published in *Marine Turtle Newsletter*. This paper highlights the value of engaging industry and community participation in acquiring necessary field data and the difficulty also of building on that collaboration in seeking essential population demographic data for juvenile turtles.
- Technical solution to displaying tag and release location and recovery point connections for flipper tagged turtles developed with GIS Applications group.
- Review of database systems initiated. This is required to expedite further modelling collaborations that depend on efficient data management, extraction of information for the particular tasks involved, and the presentation of summaries and production of maps, graphs, and figures for publications.

Management implications

The provision of this further necessary knowledge will assist the development of appropriate conservation and management programs of marine turtle stocks in Western Australia to minimise the impacts of human activities on these animals.
Similar problems are anticipated to arise for necessary analysis of the other foundation adult female C–M–R population data sets.

Future directions (next 12 to 18 months)

- This project is being included as part of the broader review of turtle research and monitoring in DEC now in progress.
- Analysis of existing datasets will be undertaken on the loggerhead population on Dirk Hartog Island and on the hawksbill population on Rosemary Island.

Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010–2015

CF 2011-122

Team members

S Wilson, A Kendrick, C Simpson

Context

Historically, much of the research needed to inform DEC's marine conservation and management programs has been delivered through externally-funded programs such as the Northwest Shelf Joint Environmental Management Study, the Strategic Research Fund for the Marine Environment and Western Australian Marine Science Institute. Although a small research capacity has recently

been established within DEC Marine Science Program, external delivery of research will remain a key mechanism to meet DEC's marine research needs for the foreseeable future.
A strategic marine research plan is being developed to ensure that DEC marine research needs are identified, prioritised and delivered in a timely manner so that appropriate scientific information is available to support DEC's marine protected areas, marine fauna management and marine environmental protection programs. The document will outline a systematic framework to identify and prioritise DEC's marine research needs, the opportunities and constraints to meeting these needs and the strategies needed to take advantage of the opportunities and overcome the constraints.

Aims

Develop and progressively implement a strategic marine research plan to support Western Australia's marine protected areas, marine fauna management and marine environmental protection programs.

Summary of progress and main findings

- A paper on research and monitoring priorities in marine protected areas has been submitted to the *Journal of Environmental Management*. The study collates research priorities identified by managers and scientists around Australia and examines their perceptions of research requirements.
- A paper on the baseline water quality at Jurien Bay Marine Park is in press at *Conservation Science Western Australia*.

Management implications

Development and implementation of the strategic marine research plan will enhance DEC's capacity to identify, prioritise and deliver DEC's marine research needs for departmental marine conservation and management programs.

Future directions (next 12 to 18 months)

Progressive implementation of the strategic marine research plan.

The Western Australian Marine Monitoring Program (WAMMP)

SPP 2012-008

Team members

K Friedman

Context

A statewide system of marine protected areas is being established as part of Australia's National Representative System of Marine Protected Areas (MPA). Long-term monitoring of condition of environmental and related social assets, along with evaluation and reporting, is a recognised State priority, and cross-jurisdictional matters of significance are receiving greater recognition on the road to national environmental accounting. DEC's Western Australian Marine Monitoring Program (WAMMP) is a statewide, long-term, institutional marine monitoring, evaluation and reporting (MER) program currently being developed and implemented to assess and increase the efficiency and effectiveness of MPA and threatened marine fauna biodiversity conservation and management programs.

Aims

Develop and implement a long-term, state-wide marine protected area and threatened marine fauna monitoring program in Western Australia.

Summary of progress and main findings

- A draft strategic plan to guide WAMMP has been developed and is currently being finalised.
- A draft manuscript describing the framework and process components has been written.
- A series of guideline documents for the selection of condition, pressure and response indicators, and the delivery of MER in MPAs and across the state has been written.
- A draft manuscript describing the operational framework to support the annual Marine Parks and Reserves Authority review process has been written.
- Time-series condition, pressure and (management) response information metrics collected through WAMMP were used by managers to help design MPA work programs and to fulfil statutory auditing requirements.

Management implications

Long time-series datasets have value as a means of learning from past experience, improving service delivery, planning and allocating resources and demonstrating results as part of accountability to key stakeholders. This performance assessment and adaptive management framework allows conservation managers to respond appropriately to changes as they become apparent and refine approaches to managing ecological and social assets.

Future directions (next 12 to 18 months)

- Finalise and publish the WAMMP strategic plan.
- Publish a manuscript describing the framework and process components of WAMMP.
- Publish a series of guideline documents for the selection of condition, pressure and response indicators, and the delivery of MER in MPAs and across the state.
- Continue to increase monitoring, evaluation and reporting focus of social values, anthropogenic pressures and stakeholder participation.

WAMMP Sub-project 1: Asset knowledge review and standard operating protocol documentation

SPP 2012-013

Team members

K Friedman, C Simpson, A Kendrick, S Wilson, K Bancroft, K Onton, T Holmes, M Rule, K Waples

Context

Monitoring the status of environmental assets assists DEC to fulfil its statutory responsibilities for the conservation of the State's biodiversity, as it is recognised that the 'health' of the environment is a powerful surrogate for biodiversity conservation. Long-term, systematic, integrated marine monitoring, together with evaluation and reporting of change, is a key management strategy for measuring success of Marine Protected Area (MPA) and marine fauna management plans, as early detection of detrimental impacts facilitates responsive and active adaptive management for the conservation of marine biodiversity. Use of a Condition–Pressure–Response monitoring framework will assist managers in assessing management efficiency and effectiveness, which is a critical element of an adaptive management framework.

Aims

Develop a process to guide the writing of Asset Knowledge Reviews that identify what condition, pressure and management response indicators need to be measured, and the methods to implement the monitoring of these indicators with due consideration of scientific 'power', cost, relevant historical data and practicality.

Summary of progress and main findings

- A draft manuscript, that provides guidance on developing WAMMP Asset Knowledge Reviews, has been developed for publication in the scientific literature.
- A comprehensive review of available literature and historical information has been undertaken to provide an improved understanding of the spatial patterns of natural, anthropogenic and climate change pressures on key marine biodiversity assets in Western Australia, to assist the development of specific asset knowledge reviews.
- Draft manuscripts of the Asset Knowledge Reviews for fish, seagrass, mangrove, little penguins, coastal biological communities and water quality have been prepared for publication.
- A draft manuscript describing an information management system for long-term institutional marine biodiversity monitoring programs has been prepared for publication.

Management implications

Monitoring, evaluation and reporting programs are a key element in the adaptive management cycle and are aimed at continuously improving the efficiency and effectiveness of DEC's conservation and management programs. Using the most representative and effective indicators assists WAMMP in delivering multi-decadal data sets to inform adaptive conservation management initiatives.

Future directions (next 12 to 18 months)

- Publish Asset Knowledge Reviews for key marine biodiversity assets.
- Complete draft Asset Knowledge Reviews for dugong, sea-lions, seabirds and stromatolites.
- Refine Standard Operating Procedures as field procedures are trialled and protocols are standardised.

WAMMP Sub-project 2: Historical time-series development

SPP 2012-014

Team members

K Friedman, K Bancroft, C Simpson

Context

Extensive monitoring of the marine environment of Western Australia has been undertaken over the last three decades or more, and although many of these monitoring programs were often issue-specific and constrained in time and space, these data have significant potential to help understand historical trends in the condition of biodiversity assets, the pressures on these assets and, in some cases, the management responses to these pressures. This project will examine historical datasets from marine research and monitoring programs in Western Australia that are relevant to the objectives of WAMMP. While the main aim is to reconstruct historical trends in asset condition and pressures to extend our understanding 'backwards in time', this project will also inform the process of selecting indicators and methods and temporal and spatial scales of WAMMP monitoring programs into the future.

Aims

- Develop a framework outlining the decision rules to guide the construction of historical time-series on asset condition, pressure and management response for high priority biodiversity assets identified in Marine Protected Area (MPA) management plans and threatened species recovery plans.

- Incorporate datasets into MPA annual asset performance reports to assist managers in their management role, and more fully populate their asset report cards that are part of the Marine Parks and Reserves Authority audit process (see WAMMP sub-project 4).

Summary of progress and main findings

- A manuscript that provides guidance for the development of historical time-series has been prepared.
- A historical time-series has been completed for coral community data from Ningaloo Marine Park and a publication of a statewide metadata analysis of coral condition is currently well-progressed .
- Historical time-series development is underway for finfish and coastal communities in Ningaloo Marine Park, mangrove communities in various MPAs, and various anthropogenic pressures (e.g. boat ownership) across the state.
- Historical sea surface temperature has been collated to provide a 30-year historical time series for each marine protected area (data sharing with NOAA).

Management implications

The construction of historical time-series will capture past investment in marine research and monitoring and assist the design and data delivery within WAMMP monitoring programs. Knowledge of historical trends in marine biodiversity asset condition, pressure and management response will also facilitate an improved understanding of future trends by providing a context of change over time and variation among years. This will facilitate better understanding and improve the efficiency and effectiveness of DEC marine conservation and management initiatives.

Future directions (next 12 to 18 months)

- Finalise and publish the historical time-series development guideline manuscript.
- Continue to identify, retrieve and assess historical records of asset Condition–Pressure–Response data to create standardised historical time-series of relevance to WAMMP.

WAMMP Sub-project 3: 'Fit to park'

SPP 2012-015

Team members

K Friedman, A Kendrick, S Wilson, K Bancroft, T Holmes, M Rule

Context

This project is focussed on implementation of monitoring programs in the field using the indicators and methods identified in WAMMP Sub-project 1, with due acknowledgement of historical data identified in WAMMP Sub-project 2. The initial focus of this project will be to determine the appropriate spatial and temporal scales for monitoring. WAMMP needs to ensure that monitoring locations and monitoring timing and frequency allows biodiversity asset monitoring data to be comparable within and between major geographical areas of interest and to operate within the context of adaptive management.

Aims

- Develop guidelines for determining the spatial and temporal scales of asset Condition–Pressure–Response (CPR) monitoring programs.
- Identify the practical constraints to the implementation of WAMMP monitoring programs within geographical areas of interest.

- Progressively implement asset CPR monitoring programs for asset priorities outlined in management plans within a structured but adaptive delivery framework.
- Progressively implement asset CPR monitoring programs for threatened marine fauna according to established DEC priorities within a structured but adaptive delivery framework.

Summary of progress and main findings

- Finfish monitoring completed at Marmion, Shoalwater, Ningaloo, Montebello/Barrow Islands and Rowley Shoals marine parks.
- Coral communities monitored in Ningaloo, Montebello/Barrow Islands and Rowley Shoals MPAs. In addition, a coral community recovery assessment was completed at Coral Bay, Ningaloo Marine Park.
- Seagrass monitoring was undertaken at Shark Bay, Jurien, Marmion and Shoalwater Islands MPAs under both historical and new sampling regimes. Macroalgae monitoring was initiated at Metropolitan and Jurien marine parks.
- Mangrove monitoring was completed at Ningaloo Marine Park and significant progress was made in capturing and processing remote imagery of mangrove in all MPAs where it is listed as an asset.
- Invertebrate monitoring of settlement of rock lobster juveniles was continued in Ningaloo Marine Park. Turtle monitoring was undertaken in the Shark Bay, Ningaloo and the proposed Dampier Archipelago MPAs. A little penguin population survey and survey of breeding status was completed in the Shoalwater Islands MPA.
- Water and sediment quality monitoring was undertaken at Ningaloo Marine Park, while water temperature monitoring arrays were established and maintained in all marine parks.

Management implications

The CPR data being collected with regard to biodiversity, physical and social assets will be available for marine park coordinators and regional staff to help them assess the efficiency and effectiveness of DEC's management. The data will also be incorporated into internal DEC and Marine Parks and Reserves Authority audit processes of MPAs.

Future directions (next 12 to 18 months)

- Produce a guideline for determining the spatial and temporal scales of asset CPR monitoring, and submit for publication in a peer-reviewed journal.
- Progressively implement and document CPR monitoring programs for threatened marine fauna according to established priorities.
- Focus on integration of monitoring across assets, to improve the effectiveness and efficiency of field data collection, data post-processing and system reporting.

WAMMP Sub-project 4: MPRA/DEC audit support and management effectiveness reporting

SPP 2012-016

Team members

K Friedman, K Bancroft, C Simpson

Context

One of the statutory roles of the Marine Parks and Reserves Authority (MPRA) is to monitor the implementation of Marine Protected Area (MPA) management plans. The audit function of the MPRA is expressed in three levels of review: as an annual performance review of the progressive

implementation of MPA management plans; audit of management performance for each MPA on a periodic basis; and a ten-year audit of the implementation of the management plan.
A comprehensive MPA performance assessment report, including a CPR report card, is presented to the MPRA annually. WAMMP assists DEC regional MPA staff and DEC specialist branches in this regard, by providing asset CPR monitoring data and advice for use in 'populating' the MPRAs MPA performance assessment framework.

Aims

Assist MPA managers and DEC specialist branches in meeting DEC/MPRA audit requirements by advising on and, where appropriate, providing CPR data to 'populate' the MPA performance assessment framework the MPRA use to service their audit function.

Summary of progress and main findings

- Annual Marine Protected Area 'Management Effectiveness Reporting' reports were compiled for each State MPA for 2010/2011.
- Work-flow process to provide asset CPR monitoring reports is being implemented. This work-flow has some initiation time costs but offers more standardised and user-friendly reporting in out-going years.

Management implications

The audit process provides asset CPR time-series information annually for all Western Australian MPAs and is a statutory requirement of DEC under the CALM Act. These data are used as part of an emerging adaptive management culture by regional MPA managers to improve the efficiency and effectiveness of their management programs.

Future directions (next 12 to 18 months)

- Finalise the process to meet DEC and MPRA audit reporting requirements.
- Produce a manuscript that describes input into the auditing of DEC biodiversity conservation initiatives and outputs, and submit for publication.
- Roll-out of a systematic and standard annual process for the provision of asset CPR monitoring updates for individual assets and MPA's.
- Compile asset CPR monitoring updates into Annual Marine Protected Area 'Management Effectiveness Reports' for each State MPA for 2011-2012.

WAMMP Sub-project 5: Community participation and liaison

SPP 2012-017

Team members

K Friedman, K Waples

Context

Stakeholder engagement and participation is recognised as a key strategy to develop better links between managers, scientists and the community at large. Government, industry and community partnerships within the context of WAMMP offer the opportunity of extending the scope of an early warning system for detecting change in the marine environment and opportunities to share information and improve understanding across many marine conservation issues and priorities that are of wider interest.

Aims

- Successfully engage with stakeholders and the general community on issues of marine conservation, with special regard to WAMMP activity.

- Provide opportunities for direct involvement in monitoring, related activities and presentations of information to ensure broad involvement of the community in managing the health of the marine and coastal environment.
- Ensure the data collected by a wide range of stakeholders will complement the monitoring data collected by DEC scientists and operational managers so that together these data will be used by both DEC managers and local communities to help manage human impacts on their local marine environment.

Summary of progress and main findings

- WAMMP presentations were made to three community and five DEC groups.
- Finfish monitoring, completed by DEC at the Montebello/Barrow Islands, Shark Bay, Ningaloo and the metropolitan marine parks was undertaken in collaboration with 'Reef Life Survey', a community-based citizen science organisation.
- Coral monitoring completed in Ningaloo and Montebello/Barrow Islands MPAs with a greater involvement of commercial tour operators.
- Seabird monitoring completed by community participants at Shoalwater and Marmion marine parks.
- Volunteers were supported and trained in post-processing and reporting of coral, little penguin and seagrass monitoring information.

Management implications

The management of MPAs and threatened marine fauna will benefit from increased stakeholder understanding resulting from extensive communication of, and direct community participation in, WAMMP activity and reporting.

Future directions (next 12 to 18 months)

- Engage MER programs from other state and regional conservation agencies in sharing their strategic and annual information for the benefit of DEC, state and regional collaborators.
- Continue to support community NRM and other conservation initiatives that align with WAMMP objectives and foster industry, government agency, university, and public participation programs.

WAMMP Sub-project 6: Marine information management system

SPP 2012-018

Team members

S Whiting, K Friedman, F Mayer, C Severin

Context

The research and monitoring capacity within the Marine Science Program focuses effort on the ecological and social science needed to inform the adaptive management of Western Australia's marine protected area network, the conservation of threatened marine fauna and the conservation of the state's marine biodiversity generally. These programs will generate enormous volumes of data that must be analysed, presented and stored for future uses. To complete these tasks an information management framework is needed to support research and monitoring requirements. Information management in this context is the development and execution of architectures, policies, practices and procedures that properly manage the full data lifecycle needs of the Marine Science Program, with particular emphasis on the long-term datasets required for WAMMP.

Aims

- Establish and implement a best practice information management system for the Marine Science Program with a particular emphasis on the orderly management and presentation of long-term datasets produced by WAMMP.
- Provide a framework and process for orderly management and sharing of scientific literature, stock images and footage.

Summary of progress and main findings

- Guidelines for the Marine Science Program's data collection and information management are being aligned with data management recommendations of the Australian National Data Service and the Atlas of Living Australia.
- Two major components for data warehousing and meta-data cataloguing have been designed and are being implemented.
- A literature management system has been established.
- A bulk file storage system, with large capacity for handling of video files, has been established.
- Mobile data collection tools and protocols are being developed to WAMMP requirements.

Management implications

As the primary purpose of the monitoring and research is to acquire, evaluate and make available natural resource information to contribute to adaptive management, a well structured data handling and archive system is a critical component for management. Ordered, accessible and secure data derived from long-term monitoring studies and research projects offer managers an insight into work that has been completed. Having the raw data from past studies limits the duplication of work and offers the opportunity for reassessment if new questions arise.

Future directions (next 12 to 18 months)

- Publish the three-year Marine Science Strategic Plan for Information Management.
- Provide a future-proof, standardised storage solution for long-term monitoring data sets.
- Provide a metadata catalogue to make data sets discoverable and accessible.
- Develop methods and work flows to enter and retrieve data from these solutions.

Establishment of a long-term monitoring program for the proposed Dampier Archipelago Marine Park

SPP 2008-002

Team members

C Simpson, S Armstrong, K Bancroft

Context

The proposed Dampier Archipelago Marine Park (DAMP) is located off the north-west coast of Western Australia approximately 1650 km north of Perth. The area comprises of a wide range of marine habitats that support diverse marine biota, including more than 736 fish species and 230 scleractinian coral species, making the Dampier Archipelago the second most diverse site in Western Australia for hard corals. The marine environment of the area has considerable regional ecological and social conservation significance and is subject to increasing human use, including major offshore oil and gas production and associated port development. The region is also subject to a range of commercial and recreational fishing activities and the Dampier area has the highest per capita boat ownership in Western Australia.

Trends in resource condition over time are essential for assessment of the effectiveness of the proposed management regime for the DAMP. This project has established long-term monitoring sites, using a before-after control-impact (BACI) design, to obtain data on the abundance of selected finfish species and the cover of benthic reef communities 'before' the zoning scheme is implemented. These data will provide estimates of the current condition of the reef and reef finfish populations at selected sites to compare with future data following the establishment of the DAMP and the implementation of the zoning scheme (i.e. comparisons between sanctuary and non-sanctuary zones). The data will also be compared to historical data to provide a longer-term temporal perspective.

Aims

Monitor targeted finfish abundance and length and rock lobster density such that any differences over time between protected and non-protected zones of the DAMPA can be detected.

Summary of progress and main findings

Two data reports have been completed.

Management implications

The project will provide information trends in resource condition over time for assessment of the effectiveness of the proposed management regime. It will increase understanding on the condition of Dampier Archipelago coral reef communities and the reef fish communities. It will increase public awareness of conservation value of the Dampier Archipelago.

Future directions (next 12 to 18 months)

This project has been moved under SSP 2012-015 WAMMP Sub-Project 3 'Fit to Park' and this SPP will be formally closed.

Spatial and temporal patterns in benthic invertebrate communities of the Walpole and Nornalup Inlets Marine Park

SPP 2009-013

Team members

A Kendrick, M Rule

Context

The Walpole and Nornalup Inlets Marine Park (WNIMP) was created in 2009 to include the entrance channel, both basins and the tidal extent of the Frankland, Deep and Walpole rivers. Invertebrates are recognised as a significant ecological value of the marine park and a key performance indicator of management effectiveness. The benthic invertebrate community of the inlets has been described from surveys conducted in 1984 and 1987. The fauna was found to be relatively diverse compared with most estuaries in the south-west of Western Australia because of the predominantly marine conditions that are sustained in the inlets. Few subsequent studies have examined this fauna, and the current knowledge of benthic invertebrates in the system is considered to be inadequate for marine reserve management. Little is known, for example, of how the fauna varies in response to the seasonal hydrological cycle.

Aims

- Determine spatial patterns in the WNIMP benthic invertebrate community.
- Determine temporal variation in the WNIMP benthic invertebrate community, particularly in relation to seasonal changes in the hydrological cycle of the inlet system.

- Assist DEC's Marine Monitoring Unit in the development of methods for long-term monitoring of benthic invertebrate communities in the WNIMP and more broadly across temperate estuarine marine protected areas.

Summary of progress and main findings

- Seasonal invertebrate sampling was completed with Frankland District staff in July 2011, October 2011, February 2012 and April 2012, and invertebrate specimens were sorted from all samples in the laboratory.
- A database is being compiled and a voucher specimen collection is being built to identify species. Species identifications are being made with the assistance of external experts.
- A second survey of large bivalves inhabiting shallow sand flats of the WNIMP was completed with staff and students from Edith Cowan University as part of an ECU/DEC undergraduate teaching collaboration.
- A paper for publication titled: *'Bivalves inhabiting shallow sand flats of a temperate estuary*' is currently in preparation.
- A *LANDSCOPE* article and two Information Sheets have been written.

Management implications

- Determining the baseline condition of the WNIMP benthic invertebrate community in relation to natural processes will enable assessment of existing or future anthropogenic impacts.
- This study will assist the implementation of long-term benthic invertebrate community monitoring by DEC's Marine Monitoring Unit and regional staff in the WNIMP.

Future directions (next 12 to 18 months)

- Field sampling, laboratory processing and database compilation will be completed.
- Another Edith Cowan University – DEC collaborative bivalve survey in 2013 will provide three years of data.
- Data analyses will be completed and publications prepared.

Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater Islands and Marmion Marine Parks

SPP 2009-002
Team members

A Kendrick, M Rule, J Huisman

Context

The Marmion Marine Park (MMP) and Shoalwater Islands Marine Park (SIMP) are located on the north and south Perth metropolitan coast, respectively. Both marine parks support a diverse range of marine conservation values ranging from various marine habitats to threatened marine fauna, and are dominated by sub-tidal and emergent limestone reefs and shallow sandy embayments. These marine parks are subject to high levels of recreational and commercial human activity due to their proximity to the Perth metropolitan area. Significant areas of intertidal reef platform occur in both mainland and island shores and as isolated offshore patch reefs. While a number of local studies of intertidal communities provide a significant regional knowledge base, the broad spatial patterns of intertidal biodiversity across both the MMP and SIMP are not adequately understood. Particular gaps exist in our knowledge of the intertidal communities of the SIMP and offshore platform reefs.

This study will determine relationships between the composition of these communities and the physical structure and location of the reefs.

Aims

- Determine the spatial and temporal patterns in the composition of intertidal reef communities in the MMP, SIMP and the proposed northern extension to the SIMP (comprising Garden Island and Carnac Islands).
- Determine if the intertidal reef communities in management zones protected from extractive activities differ from the intertidal reef communities of otherwise comparable reefs.
- Assist DEC's Marine Monitoring Unit in the development of methods for long-term monitoring of temperate west coast intertidal communities.

Summary of progress and main findings

- Seven mainland intertidal reef sites were sampled in the MMP and SIMP by MSP and Swan Coastal District staff in the summer of 2011/12. This completed field sampling for this project, which has comprised both spatial (16 sites sampled in one year) and temporal (seven sites sampled in each of three years) components.
- Voucher specimen collections of algae and invertebrates have been created as a taxonomic aid. Over 100 species of algae and over 100 species of invertebrate have been identified so far with only a relatively small number of species remaining to be identified.
- A database has been compiled and analyses of these data has commenced. Progress to date indicates that differences exist between intertidal reef communities of the MMP and SIMP, and that exposure to wave action may be a significant factor that influences community structure.
- Compilation of a monitoring guide for intertidal reefs has commenced. This identification guide to common species will assist staff undertake future intertidal reef monitoring in these marine reserves.
- A *LANDSCOPE* article and an Information Sheet were published.

Management implications

- A baseline understanding of the intertidal reef condition in the MMP and SIMP in relation to natural processes will enable assessment of current and future anthropogenic impacts.
- This study will assist the implementation of long-term intertidal reef community monitoring across Western Australia's temperate marine parks and reserves.

Future directions (next 12 to 18 months)

- Additional sites at Garden Island and Carnac Island that could not be sampled during 2011/2012 due to adverse sea conditions will be sampled during the summer of 2012/2013 if conditions permit.
- The remaining species identifications and data analyses will be completed.

Interactive effects of fishing and climate change on coral reef fish populations

SPP 2009-003

Team members

S Wilson, T Holmes

Context

Climate change and over-fishing are widely regarded as the major threats facing coral reef communities worldwide. Typically fishing has a 'top-down' effect on communities, through the removal of large predators, whilst climate change causes degradation of habitat, which affects fish that recruit, feed and shelter within corals. The independent impacts of these threats are well

studied; however, the interactive effects between fishing and climate change are yet to be examined. This interaction may be particularly important on reefs off the mid-western Western Australian coastline where per-capita boat ownership and recreational fishing pressure is extremely high.

Two critical processes that determine community structure of coral reef fish are recruitment and early post-settlement predation. It is hypothesised that the degradation of coral-associated habitat due to climate change will cause a decline in recruit numbers. Conversely, fishing will reduce abundance of large predators and increase numbers of smaller habitat-associated predators, thereby increasing post-settlement predation. Examining how changes in habitat and predators interact and influence post-settlement survival of fish will be critical to understanding the impacts on biodiversity of fish communities and fish populations.

Aims

- Determine how habitat degradation instigated by climate change and changes in predation instigated by fishing pressures affect the composition of the predator community on Western Australian coral reefs.
- Assess diet of predatory species targeted by fishers.
- Identify microhabitats preferentially used by juvenile fish.
- Assess how variation in fishing pressure and habitat complexity/composition influence predation rates on juveniles.

Summary of progress and main findings

- A paper on the diet of fish found along the north-west coast of Australia was published in *Environmental Biology of Fish*. The paper used published information to assess the diet of species targeted by fishers and explored how removal of these species may influence local trophic relations.
- A paper identifying habitat associations of juvenile fish was published in *PLoS ONE*. The study demonstrated corals of high structural complexity are important habitat for approximately half the species investigated. The study also showed algal meadows are important juvenile habitat for some species, including species targeted by fishers.
- A paper assessing extinction vulnerability of fish was published in *Ecology Letters*. This paper assessed life history characteristics and habitat associations to compare susceptibility of coral reef fish to climate change and fishing, concluding that most fish are vulnerable to only one of these stressors.
- A manuscript that identified predators of juvenile fish using remote video cameras has been accepted in the journal *Coral Reefs*. The study demonstrated that small wrasse are an important predator of juvenile fish.
- A manuscript examining processes that influence coral recovery following large scale disturbances has been submitted to the journal *Conservation Biology*. This study suggested expanding macroalgae inhibits recovery and that marine protected areas may promote recovery.
- A manuscript examining the synergistic and relative effects of habitat degradation and fishing on reef fish communities at Ningaloo has been submitted to *Marine Environmental Research*. This study demonstrated habitat complexity and structure was an important driver of fish community composition.
- A *LANDSCOPE* article and Information Sheet have been produced.
- Satellite imagery and algal samples have been collected from the Ningaloo lagoon during winter, spring and summer to assess seasonal and spatial differences in macroalgal meadows. This information has been analysed and is being prepared as a manuscript.

Management implications

Knowledge of the combined effects of fishing on fish recruitment will ensure effective management of recreational fishing, which may alleviate pressures placed on coral reef biodiversity.

The project will identify appropriate indicators for ongoing monitoring programs and identify finfish species that require protection from recreational or commercial fishing.

Future directions (next 12 to 18 months)

- Prepare a manuscript for submission on dietary assessment of fish species that are meso-predators.
- Prepare and publish data on algal communities.
- Assess the impact of 2011 coral bleaching on fish recruitment.

Spatial variation in the functional morphology of mangroves in the Shark Bay World Heritage Area

SPP 2011-003

Team members

M Rule, A Kendrick, J Huisman

Context

The Shark Bay Marine Park (SBMP) and the adjacent Hamelin Pool Marine Nature Reserve are World Heritage listed and support a diverse range of iconic marine conservation values. The ecological diversity of SBMP is high because this area is the southern distributional limit of many typically tropical species and the northern limit of many temperate species.

The mangrove communities of SBMP are the most southern, extensive mangroves on the Western Australian mainland and are recognised as a significant marine park conservation asset, and eastern Shark Bay is listed under the *Directory of Important Wetlands in Australia*. Mangroves in the SBMP display a wide variety of morphologies that are possibly related to the unique oceanographic characteristics of Shark Bay. While mangroves are a key ecological value of the SBMP, the current knowledge of these habitats is inadequate and impedes effective management in the reserve, and the broader World Heritage Area. For example, no significant areas of mangrove habitat currently exist within SBMP sanctuary zones. This project will provide the first comprehensive description of the variation among dense *Avicennia marina* stands in SBMP.

Aims

- Determine variations in the structure morphology of mangrove stands across the SBMP.
- Determine a classification of mangroves within the SBMP based on physical structure and environmental parameters.
- Identify indicators for on-going monitoring of mangrove community condition.

Summary of progress and main findings

- Fieldwork was completed and all data analysed.
- A paper on morphological variation in mangrove stands is in preparation.
- A paper on the algal community associated with mangrove pneumatophores in the SBMP is in preparation.
- An Information Sheet was produced.

Management implications

This study will identify mangroves of conservation significance in the SBMP and will provide significant information that will assist in future reviews of the SBMP management plan and zoning scheme. The data collected in this study will also assist in developing appropriate long-term monitoring indicators and methods for assessing mangrove community condition.

Future directions (next 12 to 18 months)

Publication of two peer-reviewed papers.

Survey of the distribution and abundance of New Zealand fur seals in Western Australia

SPP 2010-007

Team members

K Friedman, R Campbell, D Holley, S Comer, P Collins, J Pridham, D Lierich, J Edwards

Context

Pinnipeds are a key higher order predator in Western Australia's temperate marine ecosystems. They are predominantly found in continental shelf environments of the higher latitudes but also inhabit temperate and equatorial regions. Historically, all species of pinniped were commercially harvested for their pelts and oil during the 18–20th centuries, resulting in large-scale reductions of population size and range. Some species have made recent recoveries, such as the New Zealand fur seal (NZFS; *Arctocephalus forsteri*), whereas other species, such as the Australian sea lion (ASL; *Neophoca* cinerea), remain vulnerable to extinction. The two resident species of pinniped in Western Australia are listed as specially protected under the *Wildlife Conservation Act 1950*. In contrast to ASLs, NZFSs appear to be undergoing a range and population expansion within Western Australia, having doubled their population size between 1989 and 1999. The range expansion appears to be continuing with haul-out colonies established along the south-west coast, but the rate of population growth and current abundance is unknown.

Aims

- Determine the current geographical range and population abundance of NZFS in Western Australia and compare these data with surveys undertaken in 1989 and 1999.
- Determine the spatial variation in growth rates and density-dependent growth rates of NZFS colonies.
- Design a more cost-effective survey regime that yields spatially relevant signals of change in NZFS populations at relevant time scales for conservation and management.
- Predict the likely rates of population increase and range expansion for the design of future management programs and population survey.
- Determine the breeding activity and schedule of sympatric ASL colonies.

Summary of progress and main findings

A draft manuscript and data report have been prepared on the survey of breeding sites of NZFS that documented an increase in abundance, and three new breeding colonies.

Management implications

The development and implementation of a long-term monitoring program that is both cost-effective and logistically feasible will also allow evaluation of the natural and anthropogenic factors, including climate change, that influence the abundance and distribution of these species. These data are important in helping to understand the ecological effects of an expanding higher-order predator population. Trends in abundance and preliminary dietary information on the NZFS also suggest that there may be some competition with the threatened ASL. This information will

also allow better understanding of current and future trends in interactions with commercial fishing operations and the general public, and to manage this interaction more effectively.

Future directions (next 12 to 18 months)

This project is now complete with on-going pinniped monitoring activity being directed under SPP 2012-008 (Western Australian Marine Monitoring Program).

Regional-scale coral bleaching on Western Australian reefs

SPP 2011-008

Team members

J Moore, S Wilson, K Friedman, S Field, H Taylor, R Middlebrook, R Evans, T Holmes, G Shedrawi, M Depczynski (AIMS), N Evans (DoF), L Bellchambers (DoF), J Gilmour (AIMS), B Radford (AIMS), T Ridgway (AIMS), D Thomson (CSIRO)

Context

In Western Australia, coral reefs are key assets and provide critical habitat for a large diversity of flora and fauna. Understanding ecosystem processes that have a key role in structuring asset assemblages in our marine parks is therefore critical if we are to effectively monitor and manage Western Australian reefs in space and time. Here, as is the case worldwide, coral reefs are under increasing threats from climate and anthropogenic stressors that are eroding the resilience of reefs to ecological change. During the 2010/2011 summer, a considerable ocean warming event occurred along a approximately 1200km of Western Australian coastline. Accumulated thermal stress over this period impacted coral reefs from the Dampier Archipelago to Rottnest Island and possibly further to both the north and south.

Aims

- Determine the dynamics of water temperature fluctuations during the warming event at local to regional scales.
- Quantify the spatial and temporal extent of coral bleaching across Western Australian coral communities.
- Investigate the post-impact response of reef corals to bleaching at local to regional scales.
- Inform future management strategies detailing responses to disturbance events, including refining of temperature thresholds for bleaching in Western Australian coral reef Marine Protected Areas.

Summary of progress and main findings

- Papers have been submitted for publication in *PLoS ONE* and *Coral Reefs.*
- An Information Sheet was written and two posters presented at conferences.

Management implications

Impact and response trajectories of coral communities across Western Australian marine parks to bleaching events will better inform management of the importance of temperature stressors to corals. These results will also inform future disturbance response plans and facilitate forward planning so that DEC is better equipped to assess disturbance events, such as bleaching, in a timely fashion.

Future directions (next 12 to 18 months)

- Knowledge transfer to Exmouth and Karratha regional offices and the community.
- Finalise publications.

Comparison of underwater visual census and diver-operated video methods for assessing fish community condition in tropical and temperate coastal waters of Western Australia

SPP 2010-010

Team members

T Holmes, M Rule, R Evans, S Wilson, K Friedman, G Shedrawi

Context

In shallow, coastal waters, the condition of fish communities has traditionally been monitored, using a technique known as Underwater Visual Census (UVC). More recently, a technique for assessing finfish community condition has been developed that utilises stereo-video to capture imagery of fish communities that is later analysed in the laboratory. Known as Diver-Operated Video (DOV), this technique has potential advantages over UVC because sampling theoretically requires less scientific expertise, takes less time in the field, and data analysts have access to reference material to help identify fish. In addition, it provides a permanent record of the survey that can be checked or revisited at a later point if required. However, DOV datasets may be more costly to process and it is unclear if video imagery captures the same level of diversity and abundance as skilled divers conducting UVC.

Despite the significant amount of DOV surveys that have been completed on fish communities in Western Australia over recent years, no thorough investigation comparing the overall utility, results and cost-effectiveness of this technique with conventional UVC methods has been conducted. As such, comparable assessments need to be undertaken to assess the relative utility of these techniques in both temperate and tropical waters where the Western Australian Marine Monitoring Program (WAMMP) has monitoring responsibilities. This study will improve our understanding of historical UVC and DOV dataset compatibility and the relative costs of each method.

Aims

- Examine the comparability of the fish community dataset (diversity, abundance and size measures) resulting from collection using UVC and DOV survey techniques.
- Examine the effect of varying levels of diversity and abundance on the resulting fish community datasets when data is collected using the two techniques.
- Examine the effect of habitat complexity related to tropical and temperate marine ecosystems on the resulting fish datasets when data is collected using the two techniques.
- Assess the relative cost and practicality of both UVC and DOV techniques in the context of long-term monitoring programs in both tropical and temperate remote locations.

Summary of progress and main findings

- Field work at the Rowley Shoals, Ningaloo and Jurien Marine Parks as well as Rottnest Island has been completed and the data analysed. A draft manuscript is being prepared.
- Results from the Rowley Shoals were presented at the Australian Coral Reef Symposium.

Management implications

- Information obtained from this study will enable appropriate comparisons between historical datasets on fish communities that have been collected using both UVC and DOV methodologies.
- Evaluation of each methodology, including cost and time analysis, will provide advice to monitoring programs on which methodologies are most appropriate.

Future directions (next 12 to 18 months)

Prepare and submit a manuscript to an international journal.

Effects of the Gorgon Project dredging program on the marine biodiversity of the Montebellos/Barrow Islands Marine Protected Areas

SPP 2010-008

Team members

S Field, J Moore, R Evans, K Friedman, J Huisman, G Shedrawi

Context

The Gorgon Project (GP), which is based on Barrow Island, is one of the world's largest natural gas projects and the largest single resource natural gas project in Australia's history. The plant will include three 5-million-tonne-per-annum LNG trains, with domestic gas piped to the mainland, and a four kilometre long loading jetty for international shipping.

The GP includes a dredging program that will involve the removal and dumping of approximately 7.6M tonnes of marine sediment over a period of approximately 18 months. The Gorgon Dredging Offset Monitoring Evaluation and Reporting Project (Gorgon MER) will investigate the potential impacts of the dredging and dumping activities on selected marine communities within the Montebellos/Barrow Islands Marine Protected Areas (MBIMPA). This monitoring will also help inform future environmental impact assessments (EIA) by improving predictions of the spatial scale and nature of the likely impacts of dredging and dumping activities on sensitive marine communities. Additionally, this project will increase the knowledge base of the MBIMPA.

Aims

- Assess the nature and extent of potential impacts of the Gorgon dredging program on the condition of coral, fish and other important ecological communities of the MBIMPA.
- Determine the cause/s of any changes in the condition of the above communities, with particular focus on dredging, dumping and re-suspension of spoil.
- Assess the effects of potential confounding natural (e.g. cyclones, disease, predation, bleaching) and other anthropogenic (e.g. fishing) pressures on the condition of coral communities of the MBIMPA.
- Assess the nature and extent of the impacts from the Gorgon dredging program on the social assets of the MBIMPA.

Summary of progress and main findings

- The program for monitoring the health of coral and fish communities, as well as the key pressures on these communities was continued throughout the remainder of the dredging operations and for six months following the completion of dredging in November 2011.
- An additional survey in September 2011 provided qualitative information of the health of coral communities, in addition to quantified water reflectance to improve the algorithm used for the automation of plume dispersal mapping, using readings of total suspended solids from satellite imagery.
- A November 2011 survey quantified the coral communities at the completion of the 18-month dredging operation, while the December 2011 survey quantified the distribution of coral diseases in the MBIMPA at the completion of the dredging operations. Surveys in February and May 2012 have quantified coral, fish, macroalgal communities and selected macroinvertebrate taxa up to six months following the completion of the dredging operations.
- Monitoring of the pressure field associated with the dredging has been continued for the remainder of the Gorgon dredging operations and for six months following the completion of dredging operations.

- Monitoring of other potential natural and anthropogenic pressures on the coral and fish communities have been continued, to quantify any additional impacts to these communities through to six months post-dredging operations.

Management implications

- The program provides a baseline for assessing potential impacts and recovery of coral communities within the MBIMPA, with a particular focus on potential impacts related to the dredging program for the Gorgon Project. It also provides information that will assist DEC to protect and manage the MBIMPA.
- The data generated from this monitoring program will also complement Offset 'e' of the Pluto LNG program aimed at improving the capacity of government and industry to manage the impacts of dredging on tropical coral reef communities.

Future directions (next 12 to 18 months)

- Completion of the final project report and scientific publications.
- Dissemination of results as appropriate through publications, reports and presentations to industry, other DEC staff and government departments and the scientific community.

North West Shelf Flatback Turtle Conservation Program Strategic Plan

CF 2011-118

Team members

S Whiting, H Raudino, K Crane

Context

The North West Shelf Flatback Turtle Conservation Progam (NWSFTCP) is one of four environmental offsets for the Gorgon Gas project at Barrow Island. The purpose of the offset is to increase the conservation and protection of the Northwest Shelf Flatback Turtle Population through: surveying, monitoring and research; reducing interference to key breeding and feeding locations; and establishing information and education programs. The Marine Science Program coordinates the planning and implementation of works required for the NWSFTCP in addition to coordinating general research and monitoring of marine turtles in Western Australia. The NWSFTCP has a range of governance arrangements that include an Advisory Committee and a Panel of Experts.

Aims

- Develop a Conservation Plan for Marine Turtles in Western Australian as an overarching document to guide marine turtle conservation activities and to provide context for the NWSFTCP.
- Develop a Strategic Plan for the NWSFTCP to outline the scientific, management and communication activities over the next five years in the context of long-term goals.
- Establish the governance arrangements for the NWSFTCP.

Summary of progress and main findings

- A review of historical information relevant to marine turtle conservation in Western Australia is in progress.
- A review of international, national and state policy, legislation and other administrative arrangements relevant to marine turtle conservation in Western Australia is in progress.
- Drafts of *Conservation Plan for Marine Turtles in Western Australia* and *Strategic Plan for the NWSFTCP* have been completed.

- A pilot study to track hatchling sea turtles using acoustic array technology with transmitter tags was undertaken in collaboration with the University of Western Australia and the Australian Institute of Marine Science. The results showed the suitability of this technology with no adverse impact on the welfare of the hatchlings.

Management implications

The key purpose of this plan for the NWSFTCP is to establish a robust program of works within a strategic long-term framework. This offset fund provides an opportunity to fill key gaps in knowledge, establish long-term robust monitoring programs and deliver management outcomes.

Future directions (next 12 to 18 months)

- *Conservation Plan for Marine Turtles in Western Australia* finalised and published.
- *Strategic Plan for the NWSFTCP* finalised and published.
- The NWSFTCP Advisory Committee and Panel of Experts are approved and operating.
- The NWSFTCP is integrated with new initiatives (e.g. Kimberley Node of WAMSI 2 and NGO programs).

Review, assess and summarise historical data relevant to the management of the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area

SPP 2012-007

Team members

K Friedman, C Nutt

Context

The Pluto LNG Project Offset "d" program includes the requirement to review, assess and summarise historical data relevant to the management of the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area. Large amounts of marine environmental and social data have been collected by a range of agencies and industry in this area since the late 1970s. This project will collate and review this data.

Aims

- Identify, assess and collate existing biophysical and social datasets relevant to values listed in the indicative management plan.
- Construct historical time-series of relevance to the conservation of the marine biodiversity and the management of human activity.
- Ensure data is summarised, archived, made accessible and broadly presented to Government, industry and the local community.
- Assist the design and implementation of Pluto LNG Project Offset "d" projects (ii), (iii) and (iv).

Summary of progress and main findings

- A Technical Reference Group (TRG) consisting of representatives from key stakeholder groups was established in May 2012 and terms of reference drafted to support the functioning of this group.
- A web-based collaborative project space and online communications tool were developed and implemented in May 2012 to facilitate input and cooperation from TRG participants.

- Information housed within DEC, Western Australian Museum and Australian Institute of Marine Science, and publicly accessible information held by industry, have been reviewed and prioritised for use in the construction of historical time-series datasets.

Management implications

This project will provide an improved understanding for government, industry and the local community of historical trends in marine biodiversity asset condition and human use of this region, and the effectiveness of past management programs. It will identify existing and potential issues and risks where future management action may be needed.

Future directions (next 12 to 18 months)

- Obtain data from the relevant custodians, construct historical time-series datasets, report recommendations, and make metadata accessible to key stakeholders and the broader public.
- Transfer of knowledge and key findings to stakeholders and the broader public.

4. Marine science projects managed by other DEC Divisions during 2011/12

Some marine research and monitoring projects are managed by staff in DEC's Regional Services Division, Nature Conservation Division and Parks and Visitor Services Division. The following progress reports for 2011/12 have been provided by the Divisional Science Coordinators.

4.1 Regional Services Division

Jurien Bay Marine Park Australian sea lion pup counts

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

I Hatch, L Butcher, G Ingliss, K Crane, E Richardson, S Glac, M Dasey, and other DEC Moora District staff.

Context

Through anthropogenic pressures the west coast distribution of Australian sea lions (*Neophoca cinerea*) has contracted to a few breeding colonies. Two of these colonies are within Jurien Bay Marine Park (Buller Island and North Fishermans Island) and a third (Beagle Island) is close to the park. The species is known to have a low fecundity and show extreme reproductive site-fidelity. This site fidelity is such that where a localized extinction has occurred recolonisation of that site from other colonies is not thought to be possible. Any decline in reproductive output from an individual colony therefore represents a significant threat to the species as a whole and needs to be identified. The following monitoring has been conducted by JBMP staff: three breeding colonies are visited at least twice through the pupping season and counts are made of live newborn, moulted pups and dead pups.

Aligns with:

- Jurien Bay Marine Park Management Plan strategies 7.1.9/3 *Monitor trends in sea lion pup production each breeding season* and 8.5/1 *Develop and implement a prioritized monitoring program of key values and processes*.

Summary of progress and main findings

- Annual pup production is stable at approximately 140 to 180 pups per season at the three islands in/near JBMP.
- Pup counts have been conducted in 1988, 89,91,97,98,00,03,04,05,07,08 2010 and 2011.
- Data has been provided to external researchers.

Major activities and outputs

- Strategy 7.1.9/3 has been achieved by this program (*Monitor trends in sea lion pup production each breeding season*).

Management Implications

The main pressures on Australian sea lion populations are thought to be from fishing. Commercial and recreational western rock lobster (WRL) fishing places pressure on Australian sea lions in two ways: pups may drown in cray traps; and there may be competition for food - crayfish are thought to be a key component of sea lion diet. Exclusion devices on craypots in the area are now widely accepted by the community and this would've prevented deaths of some sub-adults each season. However, pressure on WRL stocks by over fishing could lead to declines in sea lion fecundity, which would require a management response.

Future directions

This is an ongoing program intended to run every breeding season. The next season is in mid 2013.

Jurien Bay human use monitoring program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

I Hatch, L Butcher, G Ingliss, K Crane, E Richardson, S Glac, M Dasey,

Context

Quantifying the spatial and temporal intensity of usage in and adjacent to Jurien Bay Marine Park has been conducted since 2003/04 using five main methods:

- Aerial surveys / counts of park visitors, including vehicles, camps, and vessels. There have been 54 flights April 2004 to June 2011 and records are in GIS system. Each aerial survey covers approximately 500 km^2 and records the location activity in the marine park or on adjacent lands.
- The continuous recording of trailer traffic at Jurien Bay Marina (*MetroCount* data). There is almost continuous data recording from 12th September 2005 to July 2012, with two gaps of 9 weeks in total - in all over 2300 days of data.
- Land-based patrols and recording of visitors. Sporadic records mainly from 2004;
- Gathering and collation of park visitor records from sea rescue and nearby camp grounds. Annual stats from Jurien Coastal Patrol and Sandy Cape camping 2004-2006.
- Face-to-face interviews of park users. One series of interviews Easter 2003.

The data generated from this monitoring program is used to benchmark park visitation and identify areas of high use. Aerial flight records also contain information on illegal/informal camps, cray pot locations, watercraft, vehicles and boat trailers so a variety of management issues can be addressed with the data.

Aligns with:

- Jurien Bay Marine Park Management Plan strategy 8.5/2 *Develop and maintain a database of human usage* (H-KMS)
- Activity Code EC1 – Human Use Impacts.

Summary of progress and main findings

- Some of the data for the surveys has been loaded onto databases and several GIS layers for each aerial survey have been created. Analysis has been performed on some of the data and correlations between data recorded in different methods have been used to extrapolate where data gaps exist.
- The surveys have quantified the number of number of visitors to different parts of the marine park in each month of the year. Clear annual patterns of park visitation have been identified and it is possible to extrapolate the date to estimate the total annual number of visitors to the park.
- The number of records of trailer movements are highly correlated (R^2 >0.75) with counts taken on simultaneous aerial surveys of vessels, vehicles, and general visitor numbers.
- Strategy 8.5/2 *Develop and maintain a database of human usage* (H-KMS) has been achieved.

Major activities and outputs

No major published outputs have arisen from this work other than in-house analysis for annual reporting. Key periods in the year have been identified as highest use. No significant changes is total annual park visitation are apparent from the existing data for 2006-12.

Management Implications

This data gathering provides a means to plan compliance and educational activities and provides evidence of stable park visitation rates through time. It has identified areas and periods of high/low use, poor compliance and has allowed quantification of the number of park visitors in each area.

Future directions

For 2012-13:

- The MetroCount data gathering is to be continued at the same location near Jurien Bay Marina.
- Data is to be consolidated and passed on to DEC GIS unit for wider distribution.

Jurien Bay Marine Park seagrass monitoring program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

I Hatch, L Butcher, G Ingliss, K Crane, E Richardson, S Glac, M Dasey and researchers from Edith Cowan University under the direction of Kathryn McMahon.

Context

The dominant primary producer in Jurien Bay Marine Park is the extensive beds of macrophytes which encompass several species with a variety of growth forms. These seagrass beds are range in depth from intertidal to over 10 metres in depth and are found throughout the park on sandy substratum. The health of the seagrass is a KPI in the management plan, so monitoring the health of these beds is of high importance. The monitoring program consists of:

- In *Posidonia sinuosa* beds at two locations (near Boullanger Island and near Fishermans Island) four permanent transects have been establish at three separate depths (12 transects at each location). Along each of the permanent transects six permanent steel quadrats (0.2m x 0.2m) have been placed and the seagrass shoots in each quadrat have been measured on a number of occasions.
- Within each quadrat the following measures are made: The number of shoots in the quadrat; the length of the longest seagrass leaf in the quadrat; an estimate of the percent cover in the quadrat.
- Field sampling at Boullanger Island and Fishermans Island has been conducted in 2003, 04, 05, 07, 08, 2010, 2011 and 2012.
- To extend the spatial extent of the program three new sites were added in 2012 at Cervantes Island, Kangaroo Point, and Green Island. Randomly-cast quadrats were used at these new sites only.

Aligns with:

- Jurien Bay Marine Park Management Plan strategies 7.1.4/4 *Monitor Seagrass meadows in areas at most risk from mooring and anchor damage* (KPI, H-KMS), 7.1.4/2 *Educate users of the important ecological role of seagrass communities...* (KPI, KMS) and 8.5/1 *Develop and implement a prioritized monitoring program of key values and processes* (KPI, H-KMS)

Summary of progress and main findings

- Prior studies independent to this program have been published internally by How and Lavery (2003 and 2004).
- Data compilation and analysis of JBMP data has been performed in 2007 by ECU and is presented in an internal data report.
- There are no clear overall temporal trends apparent from the data between 2003 and 2012 although there are some statistically significant differences between years at some depths.
- Benchmarking of some seagrass meadow parameters has been achieved by this program.

Major activities and outputs

- Strategy 7.1.4/4 *Monitor Seagrass meadows in areas at most risk from mooring and anchor damage* has been achieved.
- Strategy 7.1.4/2 *Educate users of the important ecological role of seagrass communities…* has been partially achieved in that relevant information is available for publication, and some has been published.
- Strategy 8.5/1 *Develop and implement a prioritized monitoring program of key values and processes* is being addressed.

Management Implications

Values for some basic parameters of seagrass meadows have been benchmarked so that change in this might be detected.

Future directions

- Data to make a methodological comparison of fixed quadrats and haphazardly-cast quadrats was collected in 2011. The outcome of this analysis may alter future monitoring protocols.
- Depending on the methodological review it is anticipated to continue this program in 2012/13, and reassess the effectiveness of the design to meet the management targets.

Jurien Bay Marine Park biodiversity monitoring program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

I Hatch, L Butcher, G Ingliss, K Crane, E Richardson, S Glac, M Dasey, K. Bancroft and researchers from the University of Tasmania under the direction of Graham Edgar.

Context

The goals of this program were/are to both identify areas of high biodiversity and representation that are worthy of being protected and to monitor change in those places through time, through a BACI-style design. The program has had two main phases: there were approximately 25 sites monitored eight times between 1999 and 2009 and an additional 17 sites that have been monitored from 2004. In summary the program consists of:

- Diver fish surveys. These consist of swum transects of 200m long whereby the diver records the species of each fish seen and the approximate size of each fish.
- Diver macroinvertebrate surveys. Within randomly cast quadrats along 200m transects counts of species sea urchins, gastropods, corals, sponges and other classes of invertebrate were made.
- Diver macroalgae surveys. Percent algal cover for several classes are estimated along transects at a number of points.

The data generated from this program has been analysed in a variety of univariate and multivariate ways to yield a wide range of diversity and temporal change data. At the start of the program it was envisioned to run the project 5 year pre zoning and 5 years post zoning and this will be achieved in 2009.

Aligns with:

- Jurien Bay Marine Park Management Plan strategies 7.1.5/2 *Initiate research programs to quantify the floral and faunal diversity in macroalgal habitat in relation to developing management targets*, 7.1.7/2 *Undertake research programs to characterize invertebrate diversity in the marine park* (H-KMS), 7.1.8/2 *Undertake research programs to characterize finfish diversity in the marine* park (KPI H-KMS) and 8.4/3 *Identify and communicate high priority scientific and social research projects to appropriate research* organisations (KPI H-KMS).

Summary of progress and main findings

All data management is undertaken by UTAS and no significant analysis or reporting has been performed by DEC staff. However, data reports have been provided and some published work has been released with the consent of DEC.

A trend of increasing mean size for breaksea cod and silver trevally through time in protected areas are reported and the lack of representative deeper areas in sanctuary zone are key findings.

- Strategy 7.1.5/2 *Initiate research programs in macroalgal habitats* (H-KMS) has been achieved.
- Strategy 7.1.7/2 *Characterize invertebrate diversity in the marine park* (H-KMS) has been achieved.
- Strategy 7.1.8/2 *Characterize finfish diversity in the marine park* (KPI H-KMS) has been achieved.
- Strategy 8.4/3 *Identify and communicate research project* (KPI H-KMS) has been achieved.

Major activities and outputs

Several internal data reports have been compiled and provided to JBMP.

Management Implications

Future rezoning of JBMP could be based on this program.

Future directions

- The before/after program reached its planned end in 2009/10.
- The sites are scheduled for re sampling in October 2012.

Jurien Bay Marine Park water quality benchmarking program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

I Hatch, L Butcher, G Ingliss, K Crane, E Richardson, S Glac, M Dasey, K. Bancroft, R. Masini.

Context

The biota of the bioregion in which Jurien Bay Marine Park is situated has evolved in an environment with very little nutrient input having few riverine sources of terrestrial nutrients. The resultant clear water and low water nutrient concentrations have favoured the growth of extensive macrophyte beds in areas that might otherwise be dominated by macroalgae or bare substratum. Changes to water clarity and nutrient concentrations are known threats to macrophyte beds. Two

water quality benchmarking programs have been conducted on different spatial and temporal scales:

- 2004/05 Monthly sampling was conducted over a 12 month period at 19 sites with analysis for toxicants, nutrients and physico-chemical WQ. Data includes: TSS, PAR, OC, NH_3, NOx, OP, Chl-a, Conductivity, Temperature, DO for most sites in monthly sampling.
- 2006, 08, 09. Four sites have been sampled over a 2 month period which included sites that had been sampled in the 2004-05 program. Data includes: TSS, PAR, OC, NH_3, NOx, OP, Chl-a, Conductivity, Temperature, DO for most sites in weekly sampling spread over 2 months.

Aligns with:

- Jurien Bay Marine Park Management Plan strategies 7.1.2/3 *Establish baseline water quality monitoring program in relation to nutrient enrichment* (KPI, H-KMS) and 8.5/1 *Develop and implement a prioritized monitoring program of key values and processes* (KPI, H-KMS)

Summary of progress and main findings

- Data compilation and analysis has been performed in some depth for the 2004-05 data and this showed that the overall the water quality of the area was good. The Jurien Marina was identified as have eutrophication and algae problems. Presented in Data Report: MMS/CWC/JBMP-83/2005
- Analysis of the 2006-09 data found that there were no clear temporal or spatial trends in the study period and that for many nutrient analytes the concentration of nutrients was close to or below analytical detection limits. In particular N as NOx and NH_3 were not present in measurable concentrations in most samples for 2009. Chl-a was low and variable but above detectable limits in the study period. The concentration of Chlorophyll - a was greatest at the site closest to Jurien Bay town (PI3) and this could constitute an impact of nutrient enrichment from the community, though the concentration was below acceptable limits (mean of 0.56 µg/L).

Major activities and outputs

- Strategy 7.1.2/3 has been achieved (Establish baseline water quality monitoring program in relation to nutrient enrichment) and a possible location of nutrient enrichment to the nearshore waters has been identified.
- Future changes in water quality parameters can be identified from established baseline data.

Management Implications

The suspected low ambient nutrient status of the area has been verified and benchmarked for many sites in the marine park. The low rate of nutrient inputs to the system because of low runoff is a characteristic of the ecology is identified as a key process in maintaining the macrophyte beds in these locations.

Future directions

There is no plan to continue with the existing water quality monitoring program until 2012/13 as it is thought that sufficient data has been gathered for benchmarking.

Abandoned, lost or discarded fishing gear monitoring program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

M Dasey, S Glac, other District staff and Conservation Volunteers Australia.

Context

In 2009 the United Nations Environment Program (UNEP) identified Abandoned Lost or otherwise Discarded Fishing Gear (ALDFG) as a common global threat to many aspects of marine ecological processes. This includes entanglement risks to marine mammals and the introduction of plastics to marine food chains. As well, ALDFG from local commercial rock lobster fishers is an unsightly feature of many of Jurien Bay Marine Park's beaches and represents a significant impact to the natural values of the area. This program is designed to both (a) remove plastics and ALDFG that could pose a threat to marine ecosystems, and (b) improve the amenity and natural values of areas of high recreational use. As well using UN protocols some sites have been sampled to classify and quantify waste to monitor future changes in behaviour. The intention is to remove ALDFG from all 90km of the park's beaches by 2011/12:

- October 2009 – with Conservation Volunteers Australia 30km of beach was visited and all ALDFG and litter was removed.
- March 2010 – Conservation Volunteers Australia and DEC removed waste from a further 12km of beach.
- October 2010 - Conservation Volunteers Australia and DEC removed waste from a further 20km of beach.
- April 2011 - Conservation Volunteers Australia and DEC removed waste from a further 16km of beach.
- May 2012 – DEC staff removed waste from 4km of beach.

Aligns with:

- Jurien Bay Marine Park Management Plan strategies 7.1.2. *Develop an appropriate understanding of the circulation and mixing of the marine park's waters* (KPI, H-KMS) and 8.5/1 *Develop and implement a prioritized monitoring program of key values and processes* (KPI, H-KMS)

Summary of progress and main findings

- Data compilation is currently underway and no reporting has been commenced.
- Significant amounts of floats and ropes from commercial and recreational fishing have been found in the surveys,
- Transport of ALDFG has been found to be sea-breeze driven in a northern direction,
- ALDFG and litter has been found to accumulate on the southern side of shoreline features such as headlands,
- Locations of high-deposition of ALDFG have been identified and can form the focus of ongoing efforts.

Major activities and outputs

- Strategy 7.1.2 *Develop an appropriate understanding of the circulation and mixing of the marine park's waters* has been partially achieved and a knowledge of where accumulations of ALDFG occur has been established.
- Media releases reporting the program have been produced and positive local media coverage has occurred.
- Future changes in ALDFG deposition can be identified from established baseline data.

Management Implications

The removal of entanglement hazards reduces risks to Australian Sealions in the marine park. By restoring the amenity value of places with high-recreational use social values of the reserve are also enhanced. This program has been used to engage the community and could be used to raise awareness within the fishing industry of the problems associated with rogue fishing gear.

Future directions

- The intention is to visit all beaches of the marine park and remove ALDFG and recreational litter from them by 2011/12.
- The quantitative data is to be analysed at the conclusion of the program.

Fairy Tern (*Sterna nereis*) island nesting monitoring program

SPP # Unknown

Team members

M Dasey, S Glac, other District staff.

Context

The fairy tern (*Sterna nereis*) nests on islands in JBMP and is IUCN and EPBC listed as 'Vulnerable'. The species is anecdotally reported as being sensitive to human disturbance during breeding. It is potentially useful as an indicator species as it occurs and nests across a wide range of locations in WA. A single season of monitoring has been conducted in Summer of 2011/12 with observations conducted at Favorite Island, Boullanger Island, Whitlock Island, Green Islands, Wedge Island, Essex Rocks and Cervantes Islands.

Aligns with:

Jurien Bay Marine Park Management Plan strategy 7.1.6 *Implement the Turquoise Coast Island Nature Reserve Management Plan* (H)

Summary of progress and main findings

- A list of incidental sightings was compiled.
- No records of *Sterna nereis* nesting were recorded.

Major activities and outputs

- No major outputs to date. The species list has been provided to MSP.

Management Implications

This species does not show high site fidelity for nesting so the lack of fairy tern nesting found on the islands for a single year is not significant.

Future directions

- It is intended to re-survey the islands in 2012/13.

Monkey Mia dolphin monitoring program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

L Bejder, D Holley

Context

The reduction in the number of commercially licensed operators in the Red Cliff Bay area off Monkey Mia was undertaken in response to research findings evaluating long term impacts of vessel activity on Dolphins. This management action was based mainly on 2 findings: 1) a statistically significant decline of 15% (equivalent to 1 in 7 individuals) in the use of Red Cliff Bay by individual dolphins during a time period when vessel activity doubled; and 2) female

dolphins with high exposure to vessels are less successful at reproducing compared to the lower exposed females.

Follow up research is required to evaluate the effectiveness of management actions taken by DEC to restore dolphin abundance and reproductive success in Red Cliff Bay.

Specifically the objectives of this research are:

- To estimate the relative abundance of bottlenose dolphins in both 'control' and 'tourism' areas off Monkey Mia subsequent to management actions;
- Compare relative dolphin abundance estimates in both 'control' and 'tourism' areas before and after implementation of management actions; and
- To evaluate whether management implementations reverse the documented negative impacts on female reproductive success of cumulative tour and research vessel exposure.

Aligns with

- DEC Corporate Plan strategies 1.2, 2.3, 8.4, 8.5; KRA1, KRA2.
- Shark Bay Marine Park Management Plan strategies 5.5.7

Summary of progress and main findings

This project is 5 year completed of a 5 year program. Using the same modelling techniques as in the original study, and information from an additional ~2800 dolphin group encounters, analyses indicate a further 7.02% (95% CI=−19.1 to −2.8) decline per km^2 within the tourism site. One year of black box data showed that management intervention reduced slightly the total amount of time tour operators spent within the tourism site.

Major activities and outputs

Currently no reports have been produced. However all analyses are complete. An abstract of the work has been submitted for presentation at the Biennial Marine Mammal Conference, and a poster has been presented at the 2011 AMSA conference in Fremantle.

Management Implications

This project will provide the appropriate post analysis of the reduction of tour operators in the Monkey Mia exclusion zone. The desired response would be a return to or increase in abundance levels to those before the introduction of a second tour vessel within the Red Cliff Bay Area.

Future directions

The 4th annual report from the project is due. This report will include a complete analysis that will allow comparison of relative dolphin abundance within the defined areas. The final report has been delayed and a completion date is now set at 1 November 2012.

Shark Bay loggerhead turtle tagging program

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

D. Holley and District staff

Context

In 1994, the Department of Environment and Conservation (DEC) initiated as part of the Western Australian Marine Turtle Program (WAMTP) a tagging program of nesting female loggerhead turtles at Turtle Bay, Dirk Hartog Island. The tagging program utilises a mark and re-capture methodology to estimate the population size based on the ratio of tagged and non-tagged turtles surveyed annually. During each survey female turtles are intercepted as they come up on the

beach to nest. Turtles are marked using small uniquely numbered titanium turtle tags attached to the trailing edge of the fore-flipper(s) allowing turtles to be individually identified and monitored over time. The tag number/s, carapace length and condition of each turtle surveyed are entered into the WAMTP database each year. The timing of the program corresponds with a peak in the annual December to April loggerhead turtle nesting season. The WAMTP database currently holds 14 years of tagging data (approximately 6,000 records for turtles tagged at Turtle Bay since 1994) which can be used to monitor the size and health of the loggerhead turtle population nesting at Turtle Bay. The development of a long term data set is essential for undertaking effective management and determining management effectiveness, given that change in turtle population abundance/health is only detectable over long periods, given their reproductive biology and longevity.

Aligns with

- DEC Corporate Plan strategies 1.2, 2.3, 8.4, 8.5; KRA1, KRA2.
- Shark Bay Marine Reserves Management Plan strategies 5.5.4

Summary of progress and main findings

Since 1994, with the exception of 1995 and 2006, the program has been conducted annually over a two week period in January. The WAMTP dataset has not been analyzed and as such there is not a current reliable estimate of the status of the Turtle Bay loggerhead turtle nesting population. The future analysis of this long-term dataset will need to address issues relating to a change in methodologies between 2004 and 2007 which reduced sampling effort from five beaches to two.

Major activities and outputs

Annual mark recapture program continued during the 2011/2012 nesting season, with all five nesting beaches surveyed and over 1000 migrant and re-migrant turtles marked or recaptured.

Management Implications

The Turtle Bay nesting population of the endangered loggerhead turtle represents the largest rookery of this species in WA. Monitoring of this population is vital for long term maintenance of the species.

Future directions

- Define peak period for breeding season through use of remote camera monitoring, continue to utilise remote camera for daily track counts of main nesting beaches;
- Continue with the 2012/13 nesting season tagging program; and
- Assess validity of current mark recapture program for long-term monitoring against budget expenditure and personnel requirements. An assessment will be made as part of state-wide turtle monitoring and research program.

Monitoring of the Ningaloo Marine Park whale shark industry and whale sharks (*Rhincodon typus*) through industry data

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

E Wilson, P Barnes

Context

The whale shark (*Rhincodon typus*) is listed as a threatened species under WA State legislation and protected under Australian Commonwealth legislation. Internationally, the conservation status of the whale shark is recognised as “vulnerable” in the World Conservation Union Red List of Threatened Species.

The Department of Environment and Conservation (DEC) is responsible for the management of whale shark tourism interactions in the Ningaloo Marine Park under the *Wildlife Conservation Act 1950*. Whale sharks are seasonally present in this marine park and these animals have become the focal point for a tourism industry that provides in-water experiences with whale sharks. DEC developed a whale shark management program in 1997 to monitor and manage human interaction with whale sharks and the industry that provides these experiences. A primary objective of the management of the whale shark interaction program is ensure that any potential impacts on individuals and the overall Ningaloo 'population' are identified in advance so that an adaptive management regime can be applied.

Every whale shark interaction conducted throughout the season is required by license conditions to be recorded in vessel logbooks by each commercial operator. This data has been recorded since 1995. However, the data required to be recorded by the operators have been changed several times over the past decade to improve the quality of the data collected. In 2008 the logbook data was finally reviewed to coincide with the development and implementation of an electronic monitoring system (EMS) to replace logbooks in 2009. Spotter pilot data has been collected from 2002 onwards.

Aligns with

- DEC Corporate Plan: Strategies 1.2, 1.3, 2.3, 7.4, 8.4, 8.5;
- Management Plan for the Ningaloo Marine Park and Muiron Islands Marine Management Area 2005-2015 Strategy 7.1.15
- Whaleshark Interaction Management Program No 27.

Aims

This project aims to review the existing whale shark industry logbook data to evaluate the utility of the data to determine industry trends and ecological parameters relating to whale sharks while in Ningaloo Marine Park. The objectives of the project are:

- to ensure ecological data collected through the whale shark interaction industry has scientific applications; and
- to track the trends over time in human pressure on the Ningaloo whale shark population
- to determine sources of error within the existing vessel logbook data set so that data accuracy and interpretation may be improved in the future.

Summary of progress and main findings

- EMS data is included in the MPRA report, see section on whale sharks
- A collaborative project, examining the spotter plane (spatial) data has been initiated

Major activities and outputs

- An annual progress report: Whale Shark Interaction Management Program No 27
- Season updates.

Management Implications

Monitoring industry trends within the whale shark industry at Ningaloo Marine Park has been on-going since 1995. In regards to ecological parameters, the data can now provide an indication of intra- and inter-seasonal variation in relative abundance. Passenger levels will give an indication of when the carrying capacity of the industry has been reached and what, if any, impacts this will have on whale shark interactions. Estimated whale shark size and gender data has been collected in vessel logbooks and some uncertainty in regards to error sources requires further analysis and research for accurate interpretation of this dataset.

DEC cautions any researcher wishing to derive statistically valid results from the log book/EMS data set to familiarise themselves first with the sources of data errors. The log books were not intended to provide stand alone scientifically rigorous population modelling but rather were developed to reflect industry trends. Little effort has been spent in the past to either train recorders or verify that data recording is occurring with accuracy and consistency. Further reviews of the EMS data and collection method are in progress to ensure that information gathered is accurate and useful to scientists and decision-makers involved in the conservation management of the whale shark of Ningaloo.

Future directions

- analysis of 2010 data and finalise 2010 annual report;
- Continue to collect and analyse data during 2011 season;
- Further analysis of aerial data to provide better search effort data that can be correlated with other factors that may have an influence on inter-seasonal variability of relative whale shark abundance; and
- Undertake more detailed size data analysis and accurate length measurements of whale sharks to assist with management actions to address the indicative trend of reduced average size.

Monitoring of coastal camping along the Ningaloo coast

SPP N/A (project initiated before Science Policy No. 78 was in place)

Team members

C. Smallwood, P. Barnes, R. Mau

Context

In order to ascertain the level of visitation in the Ningaloo Marine Park, it is important to understand the level of camping activity on the adjacent pastoral lands to the Park. A systematic monitoring program has been in place for 15 years, collecting counts of coastal camping and identifying trends in recreational activities along a set path within the April, July and October school holidays every year.

Summary of progress and main findings

There has been in increase in the numbers of campers on the Ningaloo coast over the past 15 years, although it seems with the current camping capacity the coast has reached a plateau in recent years. Camping on the Bundera (Commonwealth) defence land has also been reduced. On average, there is almost twice the number of visitors that in 1995 in 2010.

Major activities and outputs

- Coastal flights from the northern boundary of NMP to Red Bluff, on the southern boundary, are conducted on the same days in each school holiday period each year;
- The district patrol log is completed, with counts of camps, vehicles, boats, fishers, passive retreaters, commercial tours etc collection for each delineated section of the NMP.
- Each year the numbers of coastal camps are reported in the MPRA report.

Management Implications

Increased education and compliance activities will occur in peak periods and locations over time.

Rosemary Island marine turtle tagging program

SPP#: 1993/040

Team Members

M. Speirs, R Middlebrook and Karratha staff

Context

The Rosemary Island Marine Turtle Tagging Program is part of DEC's Marine Science Program 'Conservation of Marine Turtles – Western Australian Region'. The objective of this program is to obtain information on the marine turtle nesting population of Rosemary Island, including distribution, abundance and stability of the population, age structure, growth rates, nesting cycles and migratory patterns. Marine turtles were first tagged on Rosemary Island by CALM staff in the 1985-86 turtle nesting season. The program was formally established in 1993 by Dr Bob Prince with field assistance from university students and long term CALM volunteers. A targeted two week tagging program in October using beach index began in the 2003-04 turtle nesting season.

The program is conducted in October each year, lead by Karratha regional staff, and involves two weeks intense fieldwork (14 nights) tagging nesting turtles across five census beaches. All tagging data (including tag recoveries) from this program are held in DEC's Western Australian Marine Turtle Research and Monitoring (WAMTRAM) database. This program is coordinate by regional staff and heavily relies on community volunteers to assist in the field component of the program.

Aligns with

- Montebello/Barrow Islands Marine Reserves Management Plan strategies 4.5, 4.7, 7.7,9.1.11

Summary of progress and main findings

Since 1993 the program has been conducted annually over a two week period in October. The WAMTP dataset has not been analyzed and as such there is not a current reliable estimate of the status of the Hawksbill turtle nesting population. The analysis of this long-term dataset however is underway.

Major activities and outputs

The annual tagging program continued during the 2010/2011 nesting season, with all census nesting beaches surveyed with 399 turtles marked or recaptured, predominantly hawksbills.

Management Implications

The Dampier Archipelago, in which Rosemary Island lies, supports the largest hawksbill turtle rookery in the Indo-Pacific region and one of the largest in the world. Hawksbill turtles are listed as 'critically endangered' on the IUCN Red List of Threatened Species. The Rosemary Island Marine Turtle Tagging Program is a primary capture-recapture study of hawksbill turtles during their peak nesting period. It is a long standing program with one of the longest running datasets for hawksbill turtles in Australia. The program is also an important centre for training of the community and other staff members in tagging/research/monitoring in the region.

Future directions

- Define peak period for breeding season through use of remote camera monitoring, continue to utilise remote camera for daily track counts of main nesting beaches;
- Continue with the 20012/13 nesting season tagging program; and
- Assess validity of current mark recapture program for long-term monitoring against budget expenditure and personnel requirements. An assessment will be made as part of state-wide turtle monitoring and research program.

4.2 Nature Conservation Division

Marine mammal incident monitoring

SPP: N/A (project initiated before Science Policy No. 78 was in place)

Team members

D Coughran

Context

This long-term state-wide program to monitor marine mammal incidents is managed by Nature Conservation Division's Nature Protection Branch. This project documents a range of natural and anthropogenic incidents that include strandings, boat strikes, entanglements and mortalities. This monitoring may include the collection and analysis of samples from animals to provide information on their health, condition and possible causes of mortality. DEC has also supported or participated in University research on cetaceans through this program.

Aligns with:

- DEC Nature Conservation Service Strategic Plan 2010-2015, strategies 1.2.3 *Continue to effectively manage marine fauna, such as pinnipeds (seals and sea lions), little penguin, whales, whale shark, bottlenose dolphin, and dugong in State waters, to ensure ecological processes are fully maintained and threatening processes are minimized* and 1.2.4 *Regulate wildlife interaction under the Wildlife Conservation Act and manage wildlife response and emergencies.*

Summary of progress and main findings

- Anthropogenic interactions with marine mammals along the WA coast are increasing as some populations recover.
- This is particularly the case with humpback whales (*Megaptera novaeangliae*), and especially in relation to juveniles and calves.
- DEC is collaborating with the WA Department of Fisheries and the fishing industry to reduce the probability of large whale entanglements and are currently considering several mitigation measures

Major activities and outputs

This is an on-going monitoring program with a focus on collecting data and supporting or participating in research that can inform management.

Management Implications

This program documents anthropogenic and natural pressures acting on marine mammals in WA State waters. This information contributes to DEC's assessments of the condition of marine mammal populations and to the allocation of management resources.

4.3 Parks and Visitor Services Division

Marmion Marine Park visitor survey

SPP: N/A (project initiated before Science Policy No. 78 was in place)

Team members

S Debono, A Sampey, A Smith, M Tuffin

Context

The project is an extension of DEC's state-wide social monitoring program coordinated by the Social Research Unit in Parks and Visitor Services Division. The state wide social monitoring

program reports on KPIs (ie Satisfaction, Visitation) for the annual report and seeks to assess community enjoyment of park facilities and services, wildlife and the natural environment displayed in parks. The state wide survey has been slightly modified to include questions that are relevant to marine areas and associated management plans.

The objectives of the survey are:

- to determine visitors overall level of satisfaction with their visit to Marmion Marine Park
- to determine how the visitors felt about the activities in which they participated and their overall experience at Marmion Marine Park
- to determine how the visitors felt about the condition and management of the area and facilities at Marmion Marine Park
- to determine the level of knowledge of visitors in regards to zones within Marmion Marine Park
- to gain feedback on how Marmion Marine Park could be improved to better meet the needs of visitors
- to gather information on the demographic characteristics of visitors.

Aligns with:

- DEC Corporate Plan, strategies in Part 4 *Creating a world class parks system*, including 4.1 *Encourage people to enjoy nature and natural areas in appropriate ways*.
- DEC Parks and Visitor Services Strategy 2007-2011, Focus 3 *Customer satisfaction* and Focus 6 *Quality*.

Summary of progress and main findings

- The project for 2011-12 is in its data collection phase in field.

Major activities and outputs

The project is still in progress, collecting surveys in-field and as such has had no major outputs.

Management Implications

The survey will provide information about visitor satisfaction for the annual report and provide information to assess visitor expectations and perceptions of marine park management. The information collected aids in the planning and management of Marmion Marine Park in regards to site planning and design, visitor communication, business and marketing plans and performance evaluation.

Shoalwater Islands Marine Park visitor survey

SPP: N/A (project initiated before Science Policy No. 78 was in place)

Team members

S Debono, A Sampey, A Smith, M Tuffin

Context

The project is an extension of DEC's state-wide social monitoring program coordinated by the Social Research Unit in Parks and Visitor Services Division. The state wide social monitoring program reports on KPIs (ie satisfaction, visitation) for the annual report and seeks to assess community enjoyment of park facilities and services, wildlife and the natural environment displayed in parks. The state wide survey has been slightly modified to include questions that are relevant to marine areas and associated management plans.

The objectives of the survey are:

- to determine visitors overall level of satisfaction with their visit to Shoalwater Islands Marine Park

- to determine how the visitors felt about the activities in which they participated and their overall experience at Shoalwater Islands Marine Park
- to determine how the visitors felt about the condition and management of the area and facilities at Shoalwater Islands Marine Park
- to determine the level of knowledge of visitors in regards to zones within Shoalwater Islands Marine Park
- to gain feedback on how Shoalwater Islands Marine Park could be improved to better meet the needs of visitors
- to gather information on the demographic characteristics of visitors.

Aligns with:

- DEC Corporate Plan, strategies in Part 4 *Creating a world class parks system*, including 4.1 *Encourage people to enjoy nature and natural areas in appropriate ways*.
- DEC Parks and Visitor Services Strategy 2007-2011, Focus 3 *Customer satisfaction* and Focus 6 *Quality*.
- DEC Shoalwater Islands Marine Park Management Plan 2007-2017, strategies in Parts 7.7 (Monitoring) and 9.2.10 (Scientific Research):
    - *Develop and progressively implement a coordinated and prioritised ecological and social monitoring program for the marine park, including community-based monitoring programs, with a particular emphasis on MPRA and DEC audit requirements.*
    - *Facilitate social research to assess visitor expectations and perceptions of marine park management.*

Summary of progress and main findings

- The project for 2011-12 is in its data collection phase in field.

Major activities and outputs

The project is still in progress, collecting surveys in-field and as such has had no major outputs.

Management Implications

The survey will provide information about visitor satisfaction for the annual report and provide information to assess visitor expectations and perceptions of marine park management. The information collected aids in the planning and management of Shoalwater Islands Marine Park in regards to site planning and design, visitor communication, business and marketing plans and performance evaluation.

Ningaloo Tour operator visitor surveys

SPP: N/A (monitoring for licence compliance)

Team members

E Wilson, A Smith, D Rob, R Quartermain

Context

This project leads on from a pilot study conducted during the 2011 whale shark season with Ningaloo Reef Dive and Snorkel that was implemented following discussions from the sustainability audits which highlighted that operators were having problems with complying with their licence requirements in relation to visitor surveys. The pilot was held in May/June 2011 over a 6-day period and the results were presented at the 2011 whale shark post-season meeting in October 2011. At this meeting it was discussed that it would be advantageous to continue the trial, with three operators expressing interest in being involved in the continued trial. It is anticipated that additional operators will adopt the survey in future so that industry wide information can be obtained about whale shark visitor experience and satisfaction. The initial pilot was conducted

before the implementation of the Science Policy so a science project plan was not necessary at the time.

This current research is a collaborative project between various licenced Ningaloo whale shark tour operators and the Department of Environment and Conservation. The purpose of this research is to obtain data about the whale shark experience and visitor satisfaction with their whale shark experience and tour to assist with sustainability audits. It will also provide valuable information about whale shark clientele, how they source information, how often they visit and how important certain aspects are to the quality of their visit.

Aligns with:

- DEC Corporate Plan, strategies:
  - Part 4 Creating a world class parks system, including 4.1 *Encourage people to enjoy nature and natural areas in appropriate ways*.
  - Part 7 Maintaining community involvement and support, including 7.6 *Establish strategic alliances with key stakeholders working in environment, conservation, natural resource and recreational sectors*
- DEC Parks and Visitor Services Strategy 2007-2011, Focus 3 *Customer satisfaction* and Focus 6 *Quality*.
- DEC Management Plan for the Ningaloo Marine Park and Murion Islands Marine Management Area 2005-2015, strategies in part 7.1.15 (Whale sharks):
  - *Continue to implement the Whale shark Interaction Management Program No 27 with a particular emphasis on:*
  - *Ensuring continued industry compliance with the code of conduct and licence conditions*
  - *Maintaining close liaison with the industry through regular meetings of the industry/CALM committee*
  - *Ensuring effective administration of the industry by CALM*
  - *Promoting and facilitating research programs by external organisations where appropriate*
- DEC Management Plan for the Ningaloo Marine Park and Murion Islands Marine Management Area 2005-2015, strategies in part 7.2.6 (Nature-based tourism):
  - *Continue to license appropriate commercial tourism operations within the reserves with appropriate conditions including a requirement to report on their activities as part of the Park's audit process*
- DEC Whale Shark Interaction Management Program No 27 research and monitoring recommendation *Participant surveys should be regularly carried out, in collaboration with the industry, to monitor experiential and economic aspects of human/whale shark interactions*.

Summary of progress and main findings

The project is still in its in-field data collection phase for the 2011-12 whale shark season.

Major activities and outputs

The project is still in progress, collecting surveys in-field and as such has had no major outputs.

Management Implications

The survey will provide information about visitor satisfaction and other licence conditions to assist with sustainability audits of the whale shark industry and provide industry wide information about whale shark visitor experience and satisfaction.

5. MSP academic collaborations during 2011/12

MSP & Academic staff	Student & degree	Project title
A Kendrick, M Rule, G Hyndes (ECU), P Lavery (ECU)	various (u/grad)	Coastal & Marine Management course
A Kendrick, S Wilson, G Hyndes (ECU)	A Turco (PhD)	The role of *Kyphosus* spp. in reef ecosystems
A Kendrick, G Hyndes (ECU)	F Vitelli (MSc)	Feeding ecology of Pomacentridae and its ecological role in fish herbivory on temperate algal-dominated reefs
A Kendrick, M Rule, A Koenders (ECU),	various (u/grad)	Molecular Biology course
S Field, S Wilson, N Polunin (UN)	J Turner (MSc)	Monitoring coral size-frequency distribution, an investigation into digital techniques
S Field, J Majer (CU)	J Chandler (u/grad)	Settlement of corals to artificial settlement tiles
K Waples, L Bejder (MU)	H Raudino (PhD)	Population dynamics and habitat use of bottlenose dolphins (*Tursiops aduncus*) Bunbury, WA
S Wilson, E Harvey (UWA)	J Goetze (PhD)	Variation in the duration and intensity of periodic harvests and the effect on reef fish assemblages
S Wilson, T Holmes, D Bănaru (MaU)	E Ashworth (MSc)	Quantitative diet analysis of four mesopredators from Ningaloo Reef, WA
S Wilson, S Field, J Moore, T Cummings (RC)	E Jospehitis (u/grad)	Comparison of three digital image analysis techniques for assessment of coral reef bleaching
S Whiting, C McMahon (CDU)	X Hoenner (PhD)	Spatial and behavioural ecology of hawksbill turtles nesting on Groote Eylandt, NT
S Whiting, N Mitchell (UWA)	J Tedeschi (PhD)	Assessing the resilience of marine turtle embryos to extreme temperatures

Institution key: CDU=Charles Darwin University (NT), CU=Curtin University, ECU=Edith Cowan University, MU=Murdoch University, MaU= Marseille Université (France), NDU=Notre Dame University, RC=Rollins College (USA), UN=University of Newcastle (UK), UWA=University of Western Australia

6. External partnerships with MSP during 2011/12

Partnership	Project	Funding & source	DEC support (fte)
AMSA	Student Workshop, Rottnest Is.	Nil	J Moore (0.01)
AIMS	Coral reef fish recruitment study	AIMS field support	S Wilson (0.1), T Holmes (0.1)
AIMS, ANU, UWA	Functional role of macroalgal communities	$30,000	S Wilson (0.05), J Moore (0.3), K Murray (0.15), T Holmes (0.05), J Huisman (0.05)
AIMS, CSIRO, DoF	Regional-scale coral bleaching on Western Australian reefs	Nil	J Moore (0.275), S Wilson (0.075)
CSIRO	What is the role of predators at Ningaloo and how are they impacted by human use?	$55,000 & $10,000 (DEC)	S Wilson (0.1), T Holmes (0.1)
ECU	Monitoring movement patterns of marine fauna using Vemco VRAP Acoustic tracking system	Nil	A Kendrick (0.01), S Wilson (0.01)
ECU	Collaborative marine management teaching in the Walpole & Nornalup Inlets Marine Park	$2,500 (DEC)	A Kendrick (0.05), M Rule (0.05)
Chevron Australia	Fish communities of the Montebello/Barrow Islands	DEC laboratory support	S Field (0.01)
AIMS	Coral reproduction at the Montebello/Barrow Islands	DEC field support	S Field (0.01)
JCU	Use of digital imagery for coral disease assessment at the Montebello/Barrow Islands	DEC digital imagery	S Field (0.05)
JCU	The distribution of coral disease at the Montebello/Barrow Islands	DEC field support	S Field (0.05), G Shedrawi (0.05)
UWA	Connectivity of corals at the Montebello/Barrow Islands	DEC field support	S Field (0.05)
UWA	Establishing genetic guidelines for the effective ecological restoration of seagrass (ARC Linkage)	$5000 for 3 yrs	A Kendrick (0.05)
UWA, AIMS, MqU, CDU, PE	Understanding the early offshore migration patterns of turtle hatchlings and the effects of anthropogenic light – a pilot study	$47,500 (DEC) $11,000 (UWA) $5,000 (PE) $76,000 (in-kind by partners)	S Whiting (0.05)

Institution key: AIMS=Australian Institute of Marine Science, AMSA=Australian Marine Sciences Association, CDU=Charles Darwin University (NT), CSIRO=Commonwealth Scientific and Industrial Research Organisation, CU=Curtin University, DoF=Department of Fisheries, ECU=Edith Cowan University, JCU=James Cook University (Qld), MqU=Macquarie University (NSW), PE=Pendoley Environmental, UWA=University of Western Australia

7. Summary of 2011/12 MSP research projects by DEC and NRM regions

DEC	NRM	Project Title
Pilbara	Rangelands	WAMSI 1 Node 3: Science administration, coordination and integration
Kimberley	Rangelands	WAMSI 2: Kimberley Marine Research Program
Midwest, Pilbara, Kimberley	Rangelands	Conservation of marine turtles in Western Australia
All	All	Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010-2015
All	All	The Western Australian Marine Monitoring Program (WAMMP)
All	All	WAMMP Sub-project 1: Asset knowledge review and standard operating protocol documentation
All	All	WAMMP Sub-project 2: Historical time series development
All	All	WAMMP Sub-project 3: Fit to park
All	All	WAMMP Sub-project 4: MPRA/DEC audit support and management effectiveness reporting
All	All	WAMMP Sub-project 5: Community participation and liaision.
All	All	WAMMP Sub-project 6: Marine information management system.
Pilbara	Rangelands	Establishment of a long-term monitoring program for the proposed Dampier Archipelago Marine Park
Warren	South Coast	Spatial and temporal patterns in benthic invertebrate communities in the Walpole & Nornalup Inlets Marine Park
Swan	Perth	Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater Islands and Marmion marine parks
Pilbara	Rangelands	Interactive effects of fishing and climate change on coral reef fish populations
Midwest	Rangelands	Spatial variation in the functional morphology of mangroves in the Shark Bay World Heritage Area
South Coast, Warren, South West	South Coast, South West	Survey of the distribution and abundance of New Zealand fur seals in Western Australia
Midwest, Pilbara	Rangelands, Northern Agricultural	Regional-scale coral bleaching on Western Australian reefs
Midwest, Pilbara, Kimberley	Rangelands, Northern Agricultural	Comparison of underwater visual census and diver-operated video methods for assessing fish community condition in tropical and temperate coastal waters in Western Australia
Pilbara	Rangelands	Effects of the Gorgon Project dredging program on the marine biodiversity of the Montebello/Barrow islands marine protected areas
Pilbara	Rangelands	North West Shelf flatback turtle conservation program strategic plan
Pilbara	Rangelands	Review, assess and summarise historical data relevant to the management of the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area.

8. Summary of key MSP achievements during 2011-12

Key achievements for 2011-2012
The continued implementation of diverse temperate and tropical research in accordance with DEC's strategic marine research plan based on MPA management plan strategies. Current projects are examining climate change and fishing impacts on coral reefs, macroalgal community dynamics, coral bleaching, coral disease, fish community structure, mangrove ecology, benthic invertebrate ecology and intertidal reef ecology.
Significant progress towards compiling for publication a series of documents detailing the structure and proposed delivery of DEC's State-wide marine monitoring program. These include guidelines on when & where monitoring should be implemented, the incorporation of historical data, and a series of asset knowledge reviews that describe pressures, indicators and methods for monitoring particular biodiversity conservation assets.
The collection, evaluation and reporting of monitoring data for finfish, coral, seagrass, macro-algae, mangroves, invertebrates, pinnipeds, penguins, coastal communities and water quality across WA's marine protected areas. Annual MER reports have been compiled for each marine reserve.
Completion of the Ningaloo Research Program, a five year initiative conducted through WAMSI and the CSIRO Wealth from Oceans National Research Flagship and compilation of the WAMSI Node 3 final summary and synthesis report.
Initiation of the Kimberley Marine Research Program through WAMSI and coordination of the program comprising 25 proposed projects to be implemented over five years in support of marine management in the Kimberley region.
Completion of collaborative MSP/Pilbara Region fieldwork examining impacts of the Gorgon Project dredging program on the marine biodiversity of the Montebello/Barrow islands marine protected areas. Data is now being analysed and published.
Development of the North West Shelf flatback turtle conservation program, including the recruitment of staff.
Commencement of a comprehensive review of historical data relevant to the management of the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area.
Contribution to development and implementation of DEC's Policy Statement No. 78 *Science Policy* and associated guidelines.
Continued implementation of the framework to facilitate the transfer of science knowledge into DEC marine policy, planning and management frameworks.

9. Priorities for MSP over the next two to three years

Priorities for the next two to three years
Continue to develop and implement marine research in accordance with strategic priorities.
Continue to expand the implementation of WAMMP in collaboration with DEC regions.
Continue to implement a strategic and prioritised State-wide sea turtle research and monitoring program.
Oversee DEC's involvement in the Kimberley Marine Research Program (WAMSI 2)
Complete research and monitoring associated with the Gorgon Dredging offsets and implement research and monitoring associated with the Pluto and Wheatstone development offsets.

Priorities for the next two to three years
Implement strategic marine research and monitoring in the recently created Ngari Capes and Camden Sound marine parks.
Appoint a senior scientist to coordinate DEC-supported marine mammal research.
Continue to build research and monitoring capacity in the Marine Science Program.
Continue to build strategic alliances with external marine science institutions.
Increase community involvement in DEC marine science programs through community monitoring and NRM groups.

10. MSP expenditure during 2011/12

a) CF and external funding expenditure by MSP activities and projects:

Activity/Project title (CF)	DEC Region	MSP PI	Budget
Marine Science Program administration	All	C Simpson	$371,710
Committees, advice & ministerials etc	All	C Simpson	$83,753
WAMSI 1 Node 3: Science administration, coordination and integration	Pilbara	K Waples	$54,290
Conservation of marine turtles in Western Australia	Midwest, Pilbara, Kimberley	R Prince	$109,834
Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010-2015	All	S Wilson A Kendrick	$59,276
The Western Australian Marine Monitoring Program (WAMMP)	All	K Friedman	$75,881
WAMMP Sub-project 1: Asset knowledge review and standard operating protocol documentation	All	K Friedman	$75,881
WAMMP Sub-project 2: Historical time series development	All	K Friedman	$98,402
WAMMP Sub-project 3: Fit to park	All	K Friedman	$98,402
WAMMP Sub-project 4: MPRA/DEC audit support and management effectiveness reporting	All	K Friedman	$98,402
WAMMP Sub-project 5: Community participation and liaision.	All	K Friedman	$16,042
WAMMP Sub-project 6: Marine information management system.	All	K Friedman	$8,757
Establishment of a long-term monitoring program for the proposed Dampier Archipelago Marine Park	Pilbara	C Simpson	$0
Spatial and temporal patterns in benthic invertebrate communities in the Walpole & Nornalup Inlets Marine Park	Warren	A Kendrick	$72,325
Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater Islands and Marmion marine parks	Swan	A Kendrick	$49,621
Interactive effects of fishing and climate change on coral reef fish populations	Pilbara	S Wilson	$106,243
Spatial variation in the functional morphology of mangroves in the Shark Bay World Heritage Area	Midwest	M Rule	$40,274
Survey of the distribution and abundance of New Zealand fur seals in Western Australia	South Coast, Warren, South West	K Friedman	$0
Regional-scale coral bleaching on Western Australian reefs	Pilbara	S Wilson	$12,204
Comparison of underwater visual census and diver-operated video methods for assessing fish community condition in tropical and temperate coastal waters in Western Australia	Midwest, Pilbara, Kimberley	S Wilson	$35,917
Total			**$1,467,213**

Activity/Project title (external funding)	DEC Region	PI	Budget
Effects of the Gorgon Project dredging program on the marine biodiversity of the Montebello/Barrow islands marine protected areas	Pilbara	S Field	$597,641
North West Shelf flatback turtle conservation program strategic plan	Pilbara	S Whiting	$307,676
Review, assess and summarise historical data relevant to the management of the proposed Dampier Archipelago Marine Park and Regnard Marine Management Area.	Pilbara	C Nutt	$71,244
Total			**$976,561**

b) CF and external funding expenditure by CALM Act marine protected areas:

The consolidated funding (CF) budget allocations for each marine reserve or group of marine reserves have been adjusted such that allocations of MSP core funding and cross-regional projects such as WAMMP have been distributed across all relevant marine reserves.

Significant external funding was obtained for research and/or monitoring in the Ningaloo marine reserves (WAMSI node 3), Montebello/Barrow Islands marine reserves (Gorgon project offset funding) and the proposed Dampier Archipelago marine reserves (Pluto LNG project offset funding). The allocation to Camden Sound Marine Park includes development of the Kimberley Marine Science Plan.

Marine protected areas	MPA CF budget	Adjusted CF budget	External funding	Total
Camden Sound Marine Park	$121,000	$199,121	$0	$199,121
Rowley Shoals Marine Park	$0	$78,121	$0	$78,121
Montebello/Barrow Islands mpas	$164,861	$242,982	$597,641	$840,623
Proposed Dampier Archipelago mpas	$0	$0	$71,244	$71,244
Ningaloo mpas	$360,640	$438,760	$54,290	$493,050
Shark Bay mpas	$82,420	$160,541	$0	$160,541
Jurien Bay Marine Park	$0	$78,121	$0	$78,121
Metropolitan mpas	$82,420	$160,541	$0	$160,541
Walpole & Nornalup Inlets Marine Park	$30,905	$109,026	$0	$109,026
Marine Science Program core CF	$624,967	$0	$0	$0
Total	**$1,467,213**	**$1,467,213**		**$2,190,388**

11. Planned MSP expenditure for 1012/13

Activity/Project title	DEC Region	MSP PI	Budget
Marine Science Program administration	All	C Simpson	$275,543
Conservation of marine turtles in Western Australia (SPP 040/1993)	Kimberley, Pilbara, Midwest	R Prince	$88,089
Spatial and temporal patterns in benthic invertebrate communities in the Walpole & Nornalup Inlets Marine Park (SPP 013/2009)	Warren	A Kendrick	$83,037
Spatial and temporal patterns in the structure of intertidal rocky platform communities of the Shoalwater Islands and Marmion marine parks (SPP 002/2009)	Swan	A Kendrick	$78,037
Spatial variation in the functional morphology of mangroves in the Shark Bay World Heritage Area (SPP 003/2011)	Midwest	M Rule	$27,679
Interactive effects of fishing and climate change on coral reef fish populations (SPP 003/2009)	Pilbara	S Wilson	$45,263
Regional-scale coral bleaching on Western Australian reefs (SPP 008/2011)	Pilbara, Midwest, Swan	S Wilson	$7,292
Comparison of underwater visual census and diver-operated video methods for assessing fish community condition in tropical and temperate coastal waters in Western Australia (SPP 010/2010)	Pilbara, Midwest	S Wilson	$27,482
Functional role of macroalgal communities (SPP 003/2009)	Pilbara, Midwest	S Wilson	$50,774
Development of a strategic marine research plan for the Western Australian Department of Environment and Conservation: 2010-2015 (CF 121/2011)	All	A Kendrick, S Wilson	$117,929
WAMMP: Strategic planning and coordination (SPP 008/2012)	All	K Friedman	$167,630
WAMMP: Asset CPR MER (SPP 008/2012)	All	K Friedman	$350,142
WAMMP: Marine information management (SPP 008/2012)	All	K Friedman	$16,968
WAMMP: Stakeholder Participation and Communication (incl. Community MER) (SPP 008/2012)	All	K Friedman	$23,465
Total			**$1,359,332**

12. Summary of the WAMMP 2012/13 works program

1. Sub-program: Strategic Planning and Coordination

Project	Leader	Support	Where	By	External (fte)	Broad Objectives	Comments
1. Works planning and implementation of WAMMP	KFR	CSI, AKE, SWI, THO	na	mid Jul 2012		Sets out a clear program of work and on-going monitoring of work program	
2. Finalise and publish the WAMMP Strategic Plan	KFR	CSI	na	Dec-13		To clearly express the WAMMP 'big picture' for internal and external collaborators	
3. Coordinate acquisition and upgrade of marine habitat mapping (imagery purchases, ground-truthing and mapping)	KMU	Asset Leaders	All MPAs	Jun-13		Generic information need.	
4. General remote sensing support relevant to WAMMP MER (survey and reporting)	KMU	Asset Leaders	All MPAs	Jun-13		See KMU work program with aditional time of Bart Huntley	
5. Finalize and publish generic guidelines: 1) WAMMP, 2) HistTimeSeries, 3) AK Review Guide, 4) F2P, 5) Audit.	AKE	KFR, CSI, SWI,KBA,JLO	na	Dec-12		To ensure WAMMP practices and procedures are QA/QC'd via the peer review process.	
6. Continue to coordinate the finalisation and publication of outstanding Asset Knowledge Reviews (AKR's; Coral, Penguin, WQ)	AKE	All AKR authors	na	Jun-13		To ensure WAMMP practices and procedures are QA/QC'd via the peer review process.	
7. Complete New Asset Knowledge Reviews: (Dugong, SeaShoreBirds, Turtles)	KFR	Asset Leaders		Jun-13	HMarsh, JLavers, NDunlop	Self- explanatory.	
8. Formalise SOP guidelines and processes	KFR	Asset Leaders & JMO		Jun-13			
9. MSP co-ordination of Annual State of MPA reports: Asset and Issue CPR trends	KBA	KFR, Asset Leaders and MPCs	na	Sep-12		To support Regions in reporting to MPRA.	
10. All Parks annual summary report	GGO	KFR, KBA	na	End Sept-12		New design for MPRA reporting	
11. Standardised WILDERNESS (& Seascapes) definitions developed and ready for implementation in 2013-2014 reporting year	New RS SE,HU	KFR, ASM, CSI	All MPAs	Jun-13		Unnatended KPI for most MPA's. Almost a generic information need that requires procedures for aquisition.	
12. Communication Strategy	KFR	CSI, SWI, AKE	na	Jun-13		To inform internal and external participants in WAMMP of current activities and directions	
13. Develop remote camera survey technologies	KBA	Regions	SIMP (2), SBMP, WNIMP, NMP	see W-Plan	SBright, SGuy	How remote will use in WAMMP: incl. objectives, establishment, maintenance, data capture, analysis, reporting responsibilities and costs.	This task should not focus on cameras per se but information need where cameras can be used
14. WAMMP Contingency	KFR	na	na	NA		Self- explanatory.	Possible to look for external funds

2. Sub-program: Strategic Asset CPR and MER (incl Planning - annual work program; Historical time-series - CPR dataset construction; 'Fit to Park' - CPR Field Monitoring; Evaluation and Reporting - re MPRA audit process

Project	Leader	Support	Where	By	External (fte)	Broad Objectives	Comments
1. MICROBIAL COMMUNITY Condition Pressure Response (C-P-R): co-ordination of annual Monitoring, Evaluation and Reporting (MER)		DHO, AKE	HP MNR-remote			Link with Research - feed into review	
2. CORAL COMMUNITY C-P-R: co-ordination of annual MER	GSH	CSI	NMP, SBMP (remote RSMP)	see W-Plan			
3. SOFT BOTTOM COMMUNITY C-P-R: co-ordination of annual MER							
4. DEEP REEF /SUBTIDAL COMMUNITY C-P-R: co-ordination of annual MER							?
5. SEAGRASS COMMUNITY C-P-R: coordination of annual MER	MRU	KBA	SBMP, Metro (JBMP drop camera)	see W-Plan			
6. MACROALGAE C-P-R: co-ordination of annual MER	MRU	KBA	JBMP, Metro	see W-Plan			
7. MANGROVE COMMUNITY C-P-R: coordination of annual MER	KBA	THO	MBIMPAs, SBMP	see W-Plan			
8. COASTAL COMMUNITY C-P-R: coordination of annual MER	KBA	KMU	NMP	see W-Plan	?		
9. INVERTEBRATE (mobile) COMMUNITY C-P-R: coordination of annual MER	GSH	KFR	SIMP, (JBMP-UTAS) (SBMP, NMP-remote)	see W-Plan			
10. INTERTIDAL COMMUNITY C-P-R: coordination of annual MER	AKE	MRU	MMP; SIMP	AKE WP			Use data from Metro MP Inter-tidal Study
11. FINFISH COMMUNITY C-P-R: coordination of annual MER	THO	SWI, GSH,	NMP (DEC/C4C), MBIMP-industry?GDMP)	W-Plan in prep	NBarret GEdgar, CSI, RO, UWA		Ensure site selection allows SZ and non-SZ comparisons; C4C planning meetings set for Sept (and Oct when THO returns). MBIMPAs finfish done by SF et al
12. WHALE SHARKS C-P-R: coordination of annual MER			NMP-remote		0.43		Done by District staff; Condition indices (e.g. scars) will relate directly to local - scale pressures (e.g. boat strikes) rather than population estimates.
13. SHARKS RAYS C-P-R: coordination of annual MER	CSP?			TBD			
14. TURTLES C-P-R: coordination of annual MER	SWH		RSMP, MBIMPAs, NMP, SBMP	SWH WP			
15. REPTILES (non-turtle) C-P-R: coordination of annual MER							
16. DUGONG C-P-R: coordination of annual MER		DHO?	SBMP-remote	SCP-SPP in prep DHO	Amanda Hodges		Dave Holley to do?
17. PINNIPEDS C-P-R (ASL and NZFS): coord of	KFR	RCA	South/West Coast	AMMC			

annual MER & AAMC project			AMMC	Plan			
18. SEA and SHORE BIRDS C-P-R: coordination of annual MER			Remote (JBMP, WNMP, NMP, SEMP)				support for external groups activity
19. LITTLE PENGUIN C-P-R: coordination of annual MER	GSH	Regions, BCA, AKE	SIMP	see W-Plan			
20. CETACEAN (dolphin) C-P-R: coordination of annual MER		KWA					
21. CETACEAN (whales) C-P-R: coordination of annual MER		KWA					
22. WATER/SEDIMENT QUALITY C-P-R coordination of annual MER	KBA	CSI	WNIMP, MBIMP (Metro remote) (Ningaloo remote)	see W-Plan		Review WQ CPR current status and trends in priority MPAs first and recommend on-going work if appropriate. Complete temperature SOP.	WQ reviews should be in report form. Incl. the development of a WAMMP SOP that outlines how temperature data will be collected in WAMMP

3. Sub-program: Marine information management and stakeholder participation and communication

Project	Leader	Support	Where	By	External (fte)	Broad Objectives	Comments
1. Develop a Marine Information Data Storage System relevant to MSP needs, with a particular focus on WAMMP, that is consistent with national and corporate data management policies.	FMA	SWH, KFR, CSI, AKE, SWI		see W-Plan			
2. Ensure there is orderly handling of Marine Information Data (accessibilty & handling) relevant to MSP needs, with a particular focus on WAMMP. Incorporate QA and QC processes.	FMA	SWH, KFR, CSI, AKE, SWI		see W-Plan			
3. Standardise and streamline data acquisition and databasing of information collected in the Regions	FMA	CSE		see W-Plan			
1. DEC/DoF/NCB Planning -Reporting Coordination	KFR	GGO	na	Jul-13			Outputs in WAMMP SOP format.
2. Pluto Hist Timeseries + subsequent Offset D Projects (2, 3, 4)		CSI, KFR, SWI, CNU, SFI	Dampier Proposed	Jul-13			
3. Community, and National MER engagement	KFR	Asset leaders	All MPAs	as needed			

13. MSP reports to the MPRA

Simpson CJ (2007). *Marine Science Program summary of outputs and expenditure for 2006/07*. Report # 1 to the Marine Parks and Reserves Authority. Marine Science Program, Department of Environment & Conservation, Perth.

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14. MSP staff publications during 2011-12

MSP staff publications from 2007 to 2011 are listed in the 2011 MSP report to the MPRA.

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McIlgorm A, Campbell HF, **Rule MJ** (2011) The economic cost and control of marine debris damage in the Asia-Pacific region. *Ocean & Coastal Management* 54, 643-651

Harrison HB, Williamson DH, **Evans RD**, Almany GR, Thorrold SR, Russ GR, Feldheim KA, van Herwerden L, Planes S, Srinivasan M, Berumen ML, Jones GP (2012) Larval Export from Marine Reserves and the Recruitment Benefit for Fish and Fisheries. *Current Biology* 22, 1023-1028.

Krzyszczyk E, Kopps AM, Bacher K, **Smith H,** Stephens N, Meighan NA, Mann J (2012) A report on six cases of seagrass-associated gastric impaction in bottlenose dolphins (*Tursiops* sp.). *Marine Mammal Science*. doi: 10.1111/j.1748-7692.2012.00579.x

Prince RIT, Chaloupka M (2012) Estimating demographic parameters for a critically endangered marine species with frequent reproductive omission: hawksbill turtles nesting at Varanus Island, Western Australia. *Marine Biology* **159**, 355-363.

Prince RIT, Wann RH, Wann JP, Williams AEA (2012) Species, size classes, and apparent growth rates of sea turtles recorded associating with a net and trap fishery in Exmouth Gulf, Western Australia: December 1990 - June 1998. *Marine Turtle Newsletter* **134**, 3-8.

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Lin S-M, Yang S-Y, **Huisman JM** (2011) Systematic revision of the genera *Liagora* and *Izziella* (Liagoraceae, Rhodophyta) from Taiwan based on Lsu and *rbc*l sequencing analyses and carposporophyte development with description of *I. hommersandii* sp. nov. and *I. kuroshioensis* sp. nov. *Journal of Phycology* **47**, 352-365.

Keesing JK, Irvine TR, Alderslade P, Clapin G, Fromont J, Hosie AM, **Huisman JM**, Phillips JC, Naughton KM, Marsh LM, Slack-Smith SM, Thomson DP, Watson JE (2011) Marine benthic flora and fauna of Gourdon Bay and the Dampier Peninsula in the Kimberley region of north-western Australia. *Journal of the Royal Society of Western Australia* **94,** 285-301.

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Depczynski M, Heyward A, Birrell C, Colquhoun J, Radford B, O'Leary R, **Wilson SK, Holmes T**, Tinkler P (2011). *Methods for monitoring the health of benthic communities*. Coral and fish recruitment WAMSI Node 3.1.2 Final Report.

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Waples K, Simpson C (2012) *Node 3: Managing and conserving the marine estate*. Final Summary Report submitted to the Western Australian Marine Science Institution. Department of Environment and Conservation, Western Australia.

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Rule MJ, Kendrick AJ & Huisman JM (2012) *Mangroves of the Shark Bay Marine Park*. DEC Information Sheet 46/2012.

Wilson SK, Holmes T, Depczynski M (2012) *Habitat associations of juvenile coral reef fish*. DEC Information sheet 47/2012

Conference posters/abstracts/ papers

Evans R, Murray K, Shedrawi G, Field S (2011) *Digitise this! A quick and easy remote sensing method to monitor the daily extent of dredge plumes*. 48th Australian Marine Sciences Association Conference, Fremantle, 3-7 July, 2011 (Abstracts p 182).

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