Second Annual
Ningaloo Research Symposium

Discovering Ningaloo: latest findings and their implications for management

28 and 29 May 2008

Venue: Kim E. Beazley Lecture Theatre
Murdoch University
South Street
MURDOCH WA 6150

Sponsored by:

Department of Environment and Conservation,
Western Australia

CSIRO Wealth from Oceans Flagship: Ningaloo Collaboration Cluster

Murdoch University

Western Australian Marine Science Institution

TABLE OF CONTENTS

INTRODUCTION

The current major program of research in the Ningaloo Marine Park was initiated in 2005 with $5 M of funding from the Western Australian Government to address critical information gaps needed to better understand, manage and conserve Ningaloo Marine Park. The research program that was developed in consultation between the research community and resource managers aims to provide a better understanding of the marine park, its ecological resources and the effectiveness of management strategies to preserve these values.

This program of research is primarily being undertaken through Node 3 of the Western Australian Marine Science Institution (WAMSI) and through the CSIRO *Wealth from Oceans* Flagship Collaboration Fund: the Ningaloo Collaboration Cluster, hosted by Murdoch University. These research initiatives, together with core research programs funded by WA universities, industry and the Australian Institute of Marine Science, are collectively known as the Ningaloo Research Program. The Ningaloo Research Program represents a collective investment of over $30M over four years.

The first Ningaloo Research Symposium was held in July 2007 to bring together the many researchers engaged in research under the Ningaloo Research Program and additional research projects underway in the Ningaloo Marine Park. That forum encompassed a broad range of scientists and disciplines and promoted integration, links and opportunities between individuals, research projects and institutions engaged in research at Ningaloo Marine Park. Given the success of that first symposium, we hope to continue with an annual symposium to further promote the Ningaloo Research Program, enhance the collaboration of research within and between research disciplines, groups and organisations and promote knowledge transfer between scientists, resource managers and policy makers.

The theme for the Second Annual Ningaloo Research Symposium is *Discovering Ningaloo: latest findings and their implications for management.* This forum will be used to present some of the recent findings that have emerged from the last two years of research, and to highlight the management focus of the research program.

The Ningaloo Research Program is committed to making a difference at Ningaloo Marine Park. We rely on the scientists to assist by providing information that will improve our understanding and the long-term management and conservation of the marine park.

We wish you all an enjoyable and productive symposium.

Chris Simpson, Kelly Waples (Department of Environment and Conservation, WAMSI, Node 3 research)

Neil Loneragan, Irene McKissock (Murdoch University, Ningaloo Cluster)

Kate Wilson (CSIRO Wealth from Oceans)

PROGRAM

Second Annual Ningaloo Research Symposium
28 and 29 May 2008
Kim Beazley Lecture Theatre, Murdoch University

Day 1, Wednesday 28 May		
Time	**Presentation**	**Speaker**
From 8:30	Registration and coffee	
9:00	Opening	Kate Wilson (CSIRO)
9:10	Introduction and welcome	Neil Loneragan (Murdoch), Kelly Waples (DEC)
9:20	Science and management for coastal areas in a changing world – a context for the Ningaloo initiative	Keith Sainsbury (CSIRO)
Overviews – Chair: Neil Loneragan (Murdoch)		
9:50	Science and management: a framework to enhance knowledge transfer	Chris Simpson (DEC)
10:10	Modelling for management: news from Ningaloo	Beth Fulton (CSIRO)
10:30	***Morning tea***	
Biodiversity – Chair: Kelly Waples (DEC)		
11:00	Effects of zoning on exploited fish populations in the Ningaloo Marine Park	Russ Babcock (CSIRO)
11:15	Intertidal invertebrates 2007 pilot study	Bob Black (UWA)
11:30	Lagoonal and cross shelf patterns in the trophic structure of benthic fish assemblages on the Ningaloo Reef	Euan Harvey (UWA)
	Patterns in the assemblage structure of coral reef fish within and adjacent to no-take marine reserves of the Ningaloo Reef	Ben Fitzpatrick (UWA)
11:45	Ningaloo deeper water biodiversity surveys	Andrew Heyward (AIMS)
12:00	Compliance science?	Tim Green (DoF)
12:15	***Summary and discussion***	***Chris Simpson (DEC)***
13:00	***Lunch***	

Physical Environment – Chair: Mike Van Keulen (Murdoch)		
14:00	Ningaloo Reef ancestral morphology and growth history	Lindsay Collins (Curtin)
14:15	Mapping and characterising reef growth, contemporary geomorphology and sedimentary environments for conserving habitats and communities of Ningaloo	Emily Twiggs (Curtin)
14:30	Characterisation and modelling of oceanographic processes in Ningaloo Reef	Chari Pattiaratchi (UWA)
14:45	Biogeochemistry of the Ningaloo Reef	Rowena Beaton (UWA)
15:00	Mapping habitats and biodiversity of Ningaloo Reef lagoon using hyperspectral remote sensing imagery	Halina Kobryn (Murdoch)
15:15	High-resolution bathymetry and benthic cover maps for the Ningaloo Marine Park	Wojciech Klonowski (Curtin)
15:30	***Afternoon tea***	
Technology and Data Management – Chair: Bill de la Mare (CSIRO)		
15:50	Passive acoustics of Exmouth, whales and fish	Rob McCauley (Curtin)
16:05	Tagging and tracking the world's largest fish **and** The Ningaloo Reef Ecosystem Tracking Array	Conrad Speed (CDU)
16:25	Discovery and access to WA marine data - WA node of AODN	Luke Edwards (WAMSI)
16:35	Ningaloo research website	Wendy Steele (CSIRO)
16:45	***Summary and discussion***	***Bill de la Mare (CSIRO)***
17:30-18:30	***Drinks, nibblies and posters***	

Day 2, Thursday, 29 May		
Time	**Presentation**	**Speaker**
9:00	Sum-up of previous day	Neil Loneragan (Murdoch)
Socioeconomics and Human Use – Chair: Beth Fulton (CSIRO)		
9:10	High resolution mapping of reef utilisation by humans in Ningaloo Marine Park	Lynnath Beckley, *Claire Smallwood* (Murdoch)
9:25	Ningaloo Cluster Project 3: The Ningaloo destination and data modelling project	Tod Jones (Curtin)
9:40	Modelling recreational site choice for Ningaloo	Atakelty Hailu (UWA)
9:55	Modelling to monitoring: integrating research and management for the Ningaloo Coast	Jeff Dambacher (CSIRO)
	Making research count: Underpinning good communication	Geoff Syme (CSIRO)
10:10	Science for everyone	Sue McKenna (DEC)
10:30	***Morning tea***	
Regional Context: Physical and Biotic – Chair: Chris Simpson (DEC)		
11:00	Long term trends in the Leeuwin Current and implications for marine ecosystems	Ming Feng (CSIRO)
11:15	Noughts and crosses management of natural marine assets in the Gascoyne Bioregion: ecosystems, marine parks, fisheries.	Dan Gaughan (DoF)
11:30	Rapid assessment of scenario outcomes for natural resource management	Fabio Boschetti (CSIRO)
11:40	***Summary and discussion***	Chris Simpson (DEC) and Neil Loneragan (Murdoch)
12:30	***Symposium close*** ***Lunch***	

Thursday, 29 May **Afternoon workshop – attendance welcome**	
Management Strategy Evaluation - A 'flight simulator' for stakeholders **Chair – Bill de la Mare and Beth Fulton (CSIRO)**	
Time	**1:30 - 4:30**
Venue	**Kim Beazley Lecture Theatre, Murdoch University**
Topics	○ **Overview of management strategy evaluation** ○ **Misconceptions** ○ **Demystifying the process** ○ **Component parts** ○ **Closing the loop**

Workshop Context:

Management Strategy Evaluation (MSE) can seem like a complex and confusing topic. The easiest way of thinking about it is as a "flight simulator" for managers and stakeholders so they can look at the tradeoffs associated with different management options. This workshop is for anyone interested in the future management and development of the Ningaloo region. It will explain what the Ningaloo MSE model contains and identify some management options and scenarios to test. This is a great opportunity for any one interested in the region to help guide management research and to highlight any issues they would like to see addressed.

POSTERS AND ADDITIONAL ABSTRACTS

Title	Principal Author
Biodiversity	
Photo identification of manta rays in the Indo-Pacific Ocean	Florencia Cerrutti (CDU)
An analysis of sex ratio of Western Australian Humpback Whales migrating past North West Cape, Western Australia, and implications for population size estimates	Jenner, Curt (CWR)
Miliolid wall structures: Implications for the classification of the Miliolida	Justin Parker (GA)
Probability modelling using coral-reef sediments an example from Ningaloo Reef, Western Australia	Justin Parker (GA)
Loggerhead turtle (*Caretta caretta*) nest predation at Cape Range National Park	Sabrina Trocini
Spatial variation in herbivory on Ningaloo Reef	Adriana Verges (ECU)
Regional Context	
Commercial and recreational fishing of demersal scalefish within the Ningaloo Marine Park and Gascoyne region	Ross Marriott (DoF)
Physical Environment	
Habitats and biodiversity of Ningaloo Reef. Mapping the habitat components and bathymetry with hyperspectral remote sensing	Halina Kobryn (Murdoch)
A spatial and temporal framework for historical human usage data in the Ningaloo Marine Park	Claire Smallwood (Murdoch)

ABSTRACTS FOR

ORAL PRESENTATIONS

Science and management for coastal areas in a changing world – a context for the Ningaloo initiative

Keith Sainsbury

CSIRO, Marine and Atmospheric Research, GPO Box 1538, Hobart, Tasmania, 7001, Australia
keith.sainsbury@csiro.au

The Ningaloo research initiative is taking place at a unique time for the management of coastal zone areas. World-wide the intensity and range of human uses and activities has never been greater, they are increasing rapidly, and there is every reason to expect that this development pressure to continue in the foreseeable future. And at the same time global warming will have both a major effect on coastal zones and invalidate one of the fundamental assumptions of most scientific analysis and predictions. That is the assumption of process stationarity - that patterns observed in the past are a good guide to patterns in the future.

These developments pose significant challenges to science, policy and management. What will it take to achieve sustainable development in this new environment? It will be argued that adaptive management, mechanisms for regional coordination of monitoring and management responses, improved regional observation networks, and scientific evaluation of linked monitoring-adaptive management responses will be key elements for success. These elements will be discussed generally and in the context of the Ningaloo initiative.

Science and Management: a framework to enhance knowledge transfer

Chris Simpson, Alan Kendrick, Kelly Waples

Marine Science Program, Department of Environment and Conservation, Perth, WA
Chris.simpson@dec.wa.gov.au

Adaptive management is a useful framework for resource managers that relies on an ongoing process of assessment, planning and review so that management policies and practices may be improved based on outcomes. Knowledge transfer is the mechanism or pathway by which information and specialist advice flows between research, managers and policy makers and is critical to the success of this framework. However, a number of constraints have been identified in relation to knowledge transfer that inhibit effective adaptive management including those associated with differences in culture between scientists and managers, different agendas and understanding of the issues and limited communication (e.g. Briggs 2006). We seek to address these issues in relation to the Ningaloo Research Program by describing a clear process of knowledge transfer between the external research community, resource managers and policy makers and identifying mechanisms to overcome historical constraints.

Reference

Briggs, S.V. 2006. Integrating policy and science in natural resources: Why so difficult? Ecological management and Restoration 7:37-39.

Modelling for management: news from Ningaloo

E.A. Fulton, R. Gray, R. Scott, M. Sporcic

CSIRO Marine and Atmospheric Research, GPO Box 1538, Hobart, Tasmania, 7001, Australia
beth.fulton@csiro.au; ph: +61 3 62325018

Juggling the many demands on coastal marine ecosystems is a particularly uncertain and challenging task. These areas see the greatest ranges of human activities and are simultaneously the location of many ecological processes – such as production, nutrient cycling and critical life history phases. This means that the areas with the greatest role in supporting the overall system can be those most directly under pressure. Robust management is required to prevent untoward impacts degrading the value and function of these systems. Such management can not simply deal with direct impacts, but must also give consideration to indirect effects and trade-offs between components of the systems and objectives of different user groups. Models of many forms are very helpful in teasing out these issues and allowing for an informed decision making process. We will present a brief outline of how the many different modelling efforts underway on Ningaloo fit together as an information jigsaw; and how that is being built on to form a whole of ecosystem model, which is being constructed using the InVitro modelling framework. To illustrate the potential of the approach, a hypothetical example will be posed - drawing on existing ecological components (e.g. whale sharks, reefs and their associated fauna) and prototype human components (e.g. tourists or contaminant plumes).

Effects of zoning on exploited fish populations in the Ningaloo Marine Park

Russ Babcock, Mick Haywood, Mat Vanderklift, Geordie Clapin, Matt Kleczkowski, Andrew Limbourn, Richard Pillans, Darren Dennis, Tim Skewes, Dave Milton, Nicole Murphy

CSIRO Marine and Atmospheric Research, Private Bag No 5 Wembley 6913 WA
russ.babcock@csiro.au

Populations of fish targeted by recreational fishers in the Ningaloo Marine Park, were surveyed In 2006 and 2007 to assess whether populations from sanctuary zones established in 1990 differed from those in areas that were open to fishing. Herbivorous fish from major families in this functional group were also censused. A further aim of the work was to provide baseline data on populations from newly declared sanctuary zones that could be used to assess future trends in protected populations as well as across the park as a whole. Over 900 sites were surveyed over this time using underwater visual census (UVC), with effort focused on 12 sanctuary zones distributed along the length of the park. Among the species most commonly targeted by anglers there was an overall difference in abundance for just two species. The spangled emperor (*Lethrinus nebulosus*) and the yellow tailed emperor (*L. atkinsoni*), showed 2 and 3 fold increases respectively. This result applied only to fish greater than minimum legal size, not for the population as a whole. Given the fact that more than 15 years have elapsed since the implementation of no-take zoning in the park these differences are relatively small. Possible reasons for the small effect size in some species and lack of effect in others include high rates of cross-boundary movement, lack of compliance with zoning, relatively low overall fishing pressure in the area, and the high variability encountered among samples.

Intertidal invertebrates 2007 pilot study

Bob Black[1], Mike Johnson[1], Anne Brearley[2], Alan Kendrick[3], and Jane Prince[2]

[1]School of Animal Biology, University of Western Australia
[2]School of Plant Biology, University of Western Australia
[3]Department of Environment and Conservation, Exmouth
rblack@cyllene.uwa.edu.au

Our preliminary sampling of rocky, intertidal shores in Ningaloo Marine Park consisted of counts of macroinvertebrates in 452 1m^2 quadrats yielding 12867 individuals distributed among 117 species. Average abundance differed among regions: 10 sites in the north averaged 8.3 individuals per quadrat; 4 sites in the centre (Coral Bay) averaged 25.1 and 4 sites in the south (Gnarraloo Station) averaged 13.2. Two thirds of the variation in numbers of individuals was among quadrats within sites and one third was among sites within regions. In contrast to the abundances, the number of species in a collection of 1000 individuals was 57 in the north, 28 in the centre, and 40 in the south. Species accumulation curves indicate that our sampling will continue to find additional species.

Multivariate analyses of the abundances of the individual species in the assemblages at each site showed that sites are only vaguely grouped by region even though the regions do differ in species composition. Importantly, spatially close sites are not very similar.

We have, therefore, begun an inventory of species on intertidal rocky shores to which we will continue to add. We found that many species are rare as revealed by our sampling scheme (41 of the 117 species occurred as single individuals). We discovered that nearby sites vary considerably in abundances and species composition. These features will make detecting differences inside and outside sanctuary zones difficult.

Lagoonal and cross shelf patterns in the trophic structure of benthic fish assemblages on the Ningaloo Reef.

Ben Fitzpatrick[1], Euan Harvey[1] and Andrew Heyward[2]

[1] School of Plant Biology (Botany M090), University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009.
[2] AIMS, Botany & Biology Building M096, UWA, 35 Stirling Hwy, Crawley WA
fitzpb02@student.uwa.edu.au

The objectives of this research are to describe the trophic structure of demersal fish assemblages across the northern Ningaloo Reef from shallow lagoonal waters (1-10m) to deeper continental shelf habitats (90+). Specifically we are interested in how depth and habitat influence changes in the trophic structure of fish assemblages across the shelf. Sampling was undertaken using one consistent sampling technique: stereo baited remote underwater video systems (Stereo-BRUVS). Sampling was based off habitat maps produced by Curtin University and the Australian Institute of Marine Science based on combined georeferenced towed video, acoustics, aerial imagery and benthic sled data. We stratified sampling within each of 16 depth/habitat categories at four locations. In total we collected 340 stereo BRUV samples and recorded 24000 individual fish from ~420 species and measured the fork lengths of 12000 fish from stereo-video pairs. We used these fork lengths and relative abundances to calculate biomass using length-weight curves. In offshore habitats from the reef slope down, biomass was concentrated within higher trophic levels such as piscivorous and carnivorous demersal species like Carangids, Lethrinids, Lutjanids and Serranids. Habitats in shallower waters dominated by phototrophic benthos display a greater relative proportion at lower trophic levels. This is due to an abundance of herbivorous and omnivorous species like Acanthurids, Labrids and Scarids but also planctivorous and corallivorous species including Pomacentrids, and Caesonids. These findings contradict our expectation that shallow coral reefs should support higher biomass of predators due to an abundance of fish prey at lower trophic levels. One key process driving this pattern is the ontogenetic habitat shifts characteristic of many species at higher trophic levels. Species including spangled emperor (*Lethrinus nebulosus)* red emperor (*Lutjanus sebae*), red throat emperor (*L. miniatus*), goldband snapper (*Pristipomoides multidens*) and rankin cod (*Epinephelus multinotatus*) display increasing size with depth. Similarly, many species from the same family partition habitats suggesting competitive interactions might also be contributing to this pattern. For example smaller piscivorous Serranids such as *E. rivulatus* dominate shallower habitats whilst the larger bodied *E. multinotatus* dominate offshore habitats. In this instance this pattern is likely to be explained by differences in the size of available prey with inshore waters supporting smaller bodied fish and offshore supporting larger bodied fish. Another major prey represented by sediment infaunal diversity and abundance increases with depth which may also contribute to increased food for many species. Aside from these natural processes, impacts from fishing pressure in shallow water would also result in these observed patterns in trophic structure.

Patterns in the assemblage structure of coral reef fish within and adjacent to no-take marine reserves of the Ningaloo Reef.

Ben Fitzpatrick[1], Euan Harvey[1] and Russ Babcock[2]

[1] School of Plant Biology (Botany M090), University of Western Australia, 35 Stirling Highway, Crawley, Western Australia 6009.
[2] CSIRO, Floreat, Western Australia 6014.
fitzpb02@student.uwa.edu.au

The objectives of this research are to describe the assemblage structure of coral reef fish within and adjacent to long established no-take reserves at Ningaloo Reef. These reserves were chosen due to the established effects of protection quantified in previous historical baseline studies (Ayling and Ayling 1987, Westera et.al. 2003, Babcock et al unpublished data). Specifically we are interested in how differences in target species abundances influence that of the wider reef fish assemblages across major shallow lagoon habitat types. Sampling was undertaken using two techniques: stereo baited remote underwater video systems (stereo-BRUVS) which provide a relative measure of target species abundance and length frequency and stereo diver operated stereo video transects (stereo-DOVS) which provide an absolute measure of non-target species abundance and size frequency. Sampling was based off habitat maps produced by Curtin University based on combined georeferenced swam video transects, quadrats, aerial imagery and local knowledge. We stratified sampling within each of 6 main habitats at four locations, Osprey and Mandu sanctuary zones and Osprey and Mandu reference areas. In total we collected 144 stereo BRUV samples and 120 stereo DOV transects. Fish assemblage structure (species relative abundance) from stereo-BRUVS inside the two no-take reserves were highly significantly different to fish assemblages of adjacent fished areas. In a leave one out allocation success analysis, stereo BRUVs were correctly identified as a protected assemblage 88% of the time and as a fished assemblage 74% of the time. Target species contributing to this difference and significantly more abundant inside no-take zones included *Gnathanodon speciosus, Lutjanus fulviflamma, Carangoides fulvoguttatus, Epinephelus rivulatus, Lethrinus nebulosus* and *L. atkinsoni*. Fish assemblages inside no-take areas were significantly different to adjacent fished areas according to stereo-DOVs as well. Non-target species driving these differences either responded positively to protection or positively to reduced abundances of target species in fished areas. Non-target families consistently more abundant inside the protected areas included Scaridae, Mullidae, Labridae and Acanthuridae while families more abundant in fished areas included Caesonidae, Pomacentridae and some Labrids small Lethrinids and Lutjanids. Interestingly it seems that herbivores and generalist omnivores respond positively to protection whilst planktivores and possibly subordinate competitors to the main target species respond positively to fishing pressure. These data suggest that well established no-take zones maintain fished species which through various ecological interactions can influence the abundance and diversity of associated fish assemblages.

Ningaloo deeper water biodiversity surveys

Andrew Heyward

AIMS, Botany & Biology Building M096, UWA, 35 Stirling Hwy, Crawley WA
a.heyward@aims.gov.au

A collaborative, multi-disciplinary set of surveys has been undertaken within the deeper areas of Ningaloo Marine Park, between the reef crest and the WA State boundary. Evaluation of the major benthic habitat types has been undertaken using towed video transects, complimented by acoustic mapping and sediment grab collections. Representative samples of the macro-epibenthos have been collected using a benthic sled, to establish a deeper water biodiversity inventory and database. Two complete seasons of field work have resulted in video coverage at 5km spacing along the entire length of the marine park, single beam acoustic mapping at 500m spacing for the entire marine park and a comprehensive set of sediment grab samples. Additional more focused sampling has been done using multi-beam, AUV and ROV-based approaches. The final filed work is expected ot be completed in August-September 2008, with additional video surveys and a comprehensive multi-beam mapping exercise over a large proportion of the deeper areas. All field data will then be analyzed in an integrated fashion to deliver the best possible insights into the nature and distribution of the major habitats, improved bathymetry over the entire park and the establishment of a comprehensive baseline biodiversity inventory.

Compliance science?

Timothy J. Green, John Looby, Laurie Caporn and Tim Bray

WA Department of Fisheries, Locked Bay 39, Cloisters Square Post Office, WA 6850
timothy.green@fish.wa.gov.au Tel: 0417 904 684

To a scientist, the delivery of compliance may appear to be an art, but ever-greater scrutiny of budgets mean that if compliance delivery is to protect a set of values then compliance practitioners have to get smarter about delivering their services. At the same time, scientists and managers working in MPA's should be cognisant of compliance limitations because compliance failure can jeopardise much of the science in MPA's and ultimately can even threaten the values of the MPA. This may be frustrating for scientists, because while compliance service delivery (output) is becoming more scientific, evaluating the effectiveness of compliance delivery (outcome) is still very much an art.

From the perspective of compliance practitioners, compliance seems to be a poor relation in MPA management, a puzzling fact given the well-documented damage that is done to so many of the worlds marine resources whenever a high-value resource is managed under a framework that permits non-compliance (unwittingly or not).

Here we outline the risk assessment process that forms the foundation for prioritising compliance delivery to all of WA's MPA's, and how that process results in the planned delivery of appropriate compliance assets to a particular place at a particular time. Measures of compliance effectiveness are discussed and the limitations of the current processes explained.

Finally, possible ways are explored to improve the effectiveness of compliance service delivery in MPA's. These include scientists and compliance practitioners working collaboratively to identify ways of identifying non-compliant behaviour before it threatens the values of the MPA itself. Such collaborative work is essential for those outside of the compliance field to get a realistic understanding of exactly what can and what cannot be delivered to MPA's by compliance practitioners.

Ningaloo Reef ancestral morphology and growth history

Lindsay Collins, Emily Twiggs, and Alexandra Stevens

Applied Sedimentology and Marine Geoscience Group, Department of Applied Geology, Curtin University
L.Collins@curtin.edu.au

Ningaloo Reef is the fifth in a series of shoreline reef platforms developed adjacent to the rising Cape Range anticline as a response to tectonics and sea-level change. The Tantabiddi reef was a larger and earlier reef (MIS Stage 5, 125ky ago) developed during a period of stronger Leeuwin Current flow and higher sea-level, expressed as the Tantabiddi terrace, coastal scarps and rock platforms, whilst also providing the foundations for modern reef development. As a response to lower sea-levels, fed by canyons dissecting the Cape Range, alluvial fans composed of carbonate gravel encroached onto the shelf and today form part of the modern reef system. Palaeo-valleys incised the shelf at these times as found in 3-D mapping of the continental slope.

The chronology of reef growth over the last 10,000 years (MIS Stage 1 highstand at +2m, 6ky ago) is incompletely known, but it is likely that the modern reef grew as a “backstepping reef” as post-glacial sea-level rose rapidly, generating multiple development of spur and groove topography. This process continued before and after the modern reef crest became established on remnant topography provided by the old Tantabiddi reef., and availability of Tantabiddi “foundations” played a large part in the establishment of contemporary morphology (reef crest, reef flat, and lagoon).

Ancestral morphology is an integral part of the modern reef, including palaeochannel and karst conduits for terrestrial groundwater flows.

Mapping and characterising reef growth, contemporary geomorphology and sedimentary environments for conserving habitats and communities of Ningaloo

Emily Twiggs, Lindsay Collins and Sira Tecchiato

Applied Sedimentology and Marine Geoscience Group, Department of Applied Geology, Curtin University
e.twiggs@curtin.edu.au

This research aims to identify evolutionary characteristics relevant to the maintenance of marine biodiversity of the reef and continental shelf. Coring and outcrop interpretation, U-series dating and shallow seismic lines provide the data on Quaternary growth history and evolution. GIS mapping using aerial and acoustic remote sensing, alongside video transects, sediment grabs and benthic sled sampling, have been used to characterise contemporary geomorphic zonation and structure, carbonate sedimentary environments, benthic habitats and coral community assemblages.

Pleistocene foundations and ancestral topography played a major role in the establishment of Holocene reef development and are the primary physical controls on contemporary geomorphology and habitats. There is a strong transition from photozoan-reef to heterozoan-carbonate ramp producers across the shelf. Encrusting coralline algae, coral, macroalgae, turf algae and seagrass habitats thrive across geomorphic zones of the back-reef. Preliminary analysis of coral community structure and sedimentary facies has defined distinct assemblages within reef flat, lagoonal and reef pass habitats. On the shallow fore-reef slope there is a veneer of coralgal growth on multiple backstepping spur and groove systems. Hard corals are rapidly replaced by rhodolith beds at the transition from lower slope-inner shelf, providing the hard substrate for sessile filter-feeding communities. Submarine fans adjacent to reef passes complicate this pattern locally. On the open mid-outer shelf, sediment veneers over limestone pavements and large dunes are interrupted by extensive ridge and pinnacle systems. Exposed surfaces are colonised by prolific sponge, gorgonian and bryozoan “gardens”. These are prevalent near continental slope canyons, which are sites of cold water, nutrient-rich upwelling, ideal conditions for cooler-water carbonate production.

An understanding of reef evolution and the strong spatial relationships between ancestral foundations, geomorphology and contemporary ecology is essential for the ongoing conservation and management of the Ningaloo Reef.

Characterisation and modelling of oceanographic processes at Ningaloo Reef

Charitha Pattiaratchi[1], Ryan Lowe[1], Soheila Taebi[1], Greg Ivey[1] and Graham Symonds[2]

[1]School of Environmental Systems Engineering, the University of Western Australia
[2]CSIRO Division of Marine and Atmospheric Research, Floreat, WA

The response of the water circulation off Ningaloo Reef (the largest fringing coral reef in Australia) to wave, wind, and tidal forcing was studied using field data and the output from a coupled numerical circulation – wave model. A six-week field experiment measuring waves, currents, and water levels was conducted during April to May 2006. This study focused on the flow dynamics within a representative reef – channel circulation cell (one of hundreds that comprise the overall system). The results showed that wave forcing was the dominant mechanism driving the water circulation off Ningaloo Reef, with lagoonal flushing times of five to eight hours under typical offshore wave conditions. Cross-reef wave-driven currents, however, were weaker (~0.1–0.2 m/s) than expected from existing one-dimensional analytical models of reef circulation; this was likely due to the presence of the wave set-up inside the shallow lagoon, which is neglected in the analytical approaches. Preliminary results from the three-dimensional numerical model will be presented.

Recent studies have shown that under strong southerly winds, especially during summer, localised upwelling occurs along particular sections of the WA coastline, including the continental shelf region adjacent to Ningaloo Reef. Coral bleaching has occurred during prolonged periods of elevated ocean temperatures; however, extensive coral bleaching has not been observed on Ningaloo Reef, even though mass bleaching events have occurred in coral reef systems to the north of Ningaloo. The absence of coral bleaching at Ningaloo can be attributed to the oceanographic regime along the continental shelf, which, during the summer, is susceptible to wind-driven upwelling events. These events typically lower the water temperatures adjacent to the reef by 2–3 °C, thus 'insulating' the reef from higher temperatures.

Biogeochemistry of the Ningaloo Reef

Rowena Beaton, Dr. Ryan Lowe, A/Prof. Anya Waite and Dr. Jim Falter

School of Environmental Systems Engineering, the University of Western Australia
beator01@student.uwa.edu.au

Coral reefs are incredibly diverse ecosystems that are under increasing pressure from climate change. Ningaloo Reef in Western Australia has considerable intrinsic ecological and social value to the community of Western Australia, as well as attracting the interest of researchers worldwide. Reef systems are known to undergo the same biogeochemical processes as pelagic systems, although the rates, stoichiometry, spatial arrangements and governing mechanisms vary. A coral reef consists of both heterotrophic and autotrophic organisms, which can be considered together as an entire community for the purposes of studying the community metabolism and nature of the reef.

The dominant processes considered in this study are photosynthesis and integrated community respiration, both of which are aerobic and occur primarily in the benthos. Net production is the difference between community gross production (due to photosynthesis) and community respiration (including both organism respiration and decomposition), and provides an estimate of excess production of organic matter by the reef community when integrated over 24 hours or longer. It is typically close to zero in healthy reef systems.

The aim of this study was to consider the carbon and oxygen fluxes of the Ningaloo Reef community at a small (~4km) reef section of Sandy Bay on the Exmouth Peninsula. The study is based upon data collected during a 10-day field trip to the Sandy Bay site in November 2007. The study also examines the link between nutrient uptake and net carbon production on the Ningaloo Reef, which is one of the least understood processes in coral reef biogeochemistry.

Net Production was estimated using both Eulerian and Lagrangian approaches. Eulerian estimates were based upon fixed moorings of continually logging dissolved oxygen sensors, an ADCP and a CTD probe, and were calculated based upon the derivation by Falter et al (2008). Lagrangian estimates for net production and nutrient uptake were made by following parcels of water across the reef flat and manually sampling for dissolved oxygen, nitrate, soluble reactive phosphorus and chlorophyll *a*. The Lagrangian transects generated estimates of net production and nutrient uptake on different areas of the reef. These results are compared with Eulerian estimates, which show diurnal variation in net production. A graphical relationship between net production and light has also been created using the Eulerian approach. Furthermore, stoichiometric calculations using nutrient and chlorophyll *a* uptake rates suggest interesting implications for benthic-pelagic coupling over the reef flat. Further work involves refining existing calculations and developing implications for calcification on Ningaloo Reef.

Habitats and biodiversity of Ningaloo Reef. Mapping the habitat components and bathymetry with hyperspectral remote sensing

Halina T. Kobryn[1], Nicole Pinnel[1], Lynnath E. Beckley[1], Matthew M. Harvey[1], Mike van Keulen[1], Thomas Heege[2] and Peter Hausknecht[3]

[1] School of Environmental Science, Murdoch University, South St, Murdoch, WA 6150, Australia
[2] EOMAP GmbH & Co.KG, Sonderflughafen Oberpfaffenhofen, Geb. 319, D-82205 Gilching, Germany; heege@eomap.de
[3] formerly HyVista Corp., PO Box437, Baulkham Hills NSW 1755, Australia
H.Kobryn@murdoch.edu.au

This poster describes the mapping of habitats and biodiversity of the Ningaloo Marine Park as part of the Wealth from Oceans Ningaloo Collaborative Cluster. This is being achieved through a combination of state-of-the-art hyperspectral remote sensing techniques, coupled with biodiversity field surveys of the area. Airborne hyperspectral data were sponsored by BHP Billiton and collected by HyVista in April 2006 over 3400 km2 covering the whole Ningaloo Marine Park. This is the largest hyperspectral coral reef survey to date in the world which provides images at 3.5 m spatial resolution for a 1km wide terrestrial coastal strip and out to 20m depth over lagoon areas. Spectral range of the images is from 400-2500nm at 15nm interval. Hyperspectral remote sensing data are corrected for atmospheric, air-water interface and water column effects. This, physics-based approach, promotes automatisation and the removal of subjectivity from the classification process, allowing improved transferability to additional sampling locations and extension of the monitoring to other seasons. Field work to support the airborne data acquisition was carried out in 2006 and 2007, measuring underwater field spectra of cover-forming substrates, collecting echo-sounding data and underwater photographs to allow for accurate validation and interpretation of hyperspectral data. Field spectra from various habitats are used to characterise their spectral features enabling differentiation and classification of various bottom cover types. Transects across coastal vegetation were also conducted to identify the vegetation types and key landforms contributing to the variability in the images along the coast. Over the next three years, this project will use the hyperspectral data to develop a high-resolution characterisation of the reef, shallow water habitats and terrestrial vegetation of the coastal strip in order to support sound conservation and management of the Ningaloo Marine Park.

High-resolution bathymetry and benthic cover maps for the Ningaloo Marine Park

Wojciech Klonowski*, Mark Gray, Mervyn Lynch and Peter Fearns

Curtin University of Technology, Imaging and Applied Physics
wojciech.klonowski@postgrad.curtin.edu.au

Information such as bathymetry and benthic habitat cover is important for coastal zone management. This importance has been recognised by the Ningaloo Collaboration Cluster (CSIRO Flagship Project), a $12 million collaborative initiative for multi-disciplinary research of the Ningaloo Marine Park. In April 2006, the world's largest coastal hyperspectral survey was conducted over the Ningaloo Marine Park. The HyMap (HyVista Corp.) imaging system was used, capturing spectral signatures of the marine park at a ground resolution of 3.5m. Curtin University of Technology was commissioned by the Ningaloo Collaboration Cluster to process this large data set and has recently delivered high-resolution bathymetry and benthic cover maps to project partners. Validation of the bathymetry maps using historical ship-based soundings, suggests that the shallow water bathymetry maps are very accurate, with an RMS error of 13% (n=25000) for depths ranging from 0.5 to 12m. We will present the processing approach and showcases the various image outputs.

Passive acoustics off Exmouth, whales and fish

Robert McCauley[1], Curt Jenner[2], Chandra Salgado Kent[1]

[1] Centre for Marine Science and Technology, Curtin University,
[2] Centre for Whale Research (WA. Inc.).
r.mccauley@curtin.edu.au

With support from Defence and the Petroleum Industry, the Centre for Marine Science and Technology have been setting sea noise loggers along the Western Australian coast since 2000. Off Ningaloo noise loggers were set adjacent and seaward of Ningaloo reef in 2000, off NWC in 2004 and north of the Monte Bello Islands over 2005-2006. The signals of vocalising pygmy blue whales, humpbacks, Antarctic minke whales, dwarf minke whales, several fish chorus types and common but as yet unknown sources were heard. During the 2000 southern humpback whale migration a higher proportion of animals vocalised near Ningaloo reef compared with in deeper water to the west. Signal types believed to be produced by the Antarctic minke whale sub species were heard during winter months, while the tropical dwarf minke whale signals were commonly heard during spring-summer. Two pulses of vocalising pygmy blue whales have been detected off Exmouth, a northerly pulse of animals during winter and a southerly pulse over late October into late December with the peak off Ningaloo in November. A simple acoustic census technique applied to pygmy blue whale call detections suggested that in 2004, 680-1600 pygmy blue whales passed south off Exmouth, mostly in deeper water near the 500 m depth contour. Sea noise loggers set on the shelf break along the northern edge of the North West Shelf suggest that once north bound pygmy blue whales pass the northern end of the Monte Bello Islands they fan out across the northern Indian Ocean with a relatively small number following the Australian continental shelf edge. Several types of fish choruses have been heard adjacent Ningaloo, including a chorus type heard from receivers set near the shelf break which is believed associated with the oceanic deep scattering layer (as heard in the Perth Canyon), and choruses associated with nocturnal planktivorous fishes close to Ningaloo reef. Given that currently sea noise loggers are set in the Perth Canyon and on the shelf break off Scott Reef, then a strong case exists to deploy a noise logger on the shelf break west of Ningaloo to compliment the migratory pulses of whales detected at the southern and northern locations.

Tagging and tracking the world's largest fish

Meekan, M.G.[1]; Bradshaw, C.J.A.[2]; Polovina, J.J[3].; Wilson, S.[4]; Stevens, J.D.[4]

[1]Australian Institute of Marine Science, Darwin, Northern Territory, Australia
[2]University of Adelaide, Adelaide, South Australia.
[3]Pacific Islands Fisheries Science Center, NOAA Fisheries, Honolulu, Hawaii, USA
[4]CSIRO Marine and Atmospheric Research, Hobart, Tasmania, Australia
m.meekan@aims.gov.au

The past 15 years has seen rapid development of our understanding of the ecology of whale sharks (*Rhincodon typus*) that aggregate seasonally at Ningaloo Reef, Australia. Monitoring fine-scale (m-km) movements suggests that whale sharks migrate to the reef to feed on seasonal aggregations of baitfishes and euphausiids. Satellite tagging has shown that sharks departing Ningaloo make frequent dives in excess of 980 m and migrate generally toward the northeast, often into Indonesian waters. Photo-identification (based on spot and stripe patterns) has confirmed that many sharks return to the reef, with some individuals resighted at intervals of more than a decade and a large number of individuals making frequent inter-annual visits. Most sharks (74 %) individually identified in the Ningaloo aggregation from 1992-2006 have been male. Jolly-Seber open-population models suggest that sharks sighted at the reef are drawn from a super-population of 300-500 animals and Cormack-Jolly-Seber survival models demonstrate size-influenced apparent survival probability ranging from 0.59 (5-m shark) to 0.81 (9-m sharks) per year. Declines in relative abundance of up to 40 % were also evident in a 10-year sightings-per-unit effort dataset collected by tour operators. There was also a continuous decrease in the average size of whale sharks from 7 m in 1994 to 5 m in 2004. Current and future studies of include quantification of mortality sources and the development of microsatellite genetic tags, validation of photo-identification and an assessment of ocean-scale gene flow.

The Ningaloo Reef Ecosystem Tracking Array and reef shark movement patterns

Conrad Speed

Charles Darwin University
Australian Institute of Marine Science
Conrad.spped@cdu.edu.au

The Ningaloo Reef Ecosystem Tracking Array (NRETA) was designed as part of the Integrated Marine Observing System (IMOS), for monitoring the movement of sharks, rays and reef fishes. This initiative is part of the Australian Acoustic Tagging and Monitoring System (AATAMS) a nation-wide network of marine acoustic monitoring. Ninety six acoustic receivers have now been deployed in 3 curtains and 3 arrays between Coral Bay and Tantabiddi at Ningaloo Reef. A total of 132 fishes (75 sharks and rays, and 57 coral reef fishes) were tagged in Mangrove and Coral Bay between November 2007 and February 2008. Of these tagged animals, 10 sharks and 14 mantas rays were tagged in Coral Bay, and 56 sharks and rays, and 57 coral reef fishes were tagged in Mangrove Bay. There have already been 52,445 detections in the first five months from the 10 sharks tagged at Coral Bay. Juvenile blacktip sharks have only been recorded within Skeleton Bay, whereas adult blacktip sharks have been recorded both within Skeleton Bay and outside of the reef. One of the adult blacktip sharks was caught by a recreational fisher 80km to the south, outside of the marine park and another was recorded by the Mangrove Bay array (135 km to the north). A further 100 sharks will be tagged with acoustic pingers over the next 2 years at Ningaloo, of which 10 will be actively tracked. Future downloads will take place at least every six months with receivers close to the shore likely to be downloaded at a greater frequency.

Discovery and access to WA marine data - WA node of AODN

Luke Edwards

Marine Information Officer, WAMSI and iVEC
luke@ivec.org; 9266 3546

WAMSI (Western Australian Marine Science Institution), iVEC ('hub of advanced computing in Western Australia') and WASTAC (Western Australian Satellite Technology and Applications Consortium) are creating a WA node of the Australian Ocean Data Network (AODN). It will provide a data management solution for WAMSI data and information while also providing a resource for other marine researchers to securely archive their marine data and make it publicly accessible.

The WA node will be physically located at iVEC and will use the Metadata Entry and Search Tool (MEST) developed by BlueNet (and demonstrated at last year's symposium) to create metadata for WAMSI data and other WA marine data that is being archived.

The presentation will give an overview of the WA Node and discuss the data management issues of Ningaloo marine researchers in relation to this new initiative.

Ningaloo Cluster Project 3: the Ningaloo Destination and Data Modelling Project

David Wood[1], Tod Jones[1], Michael Hughes[1], Anna Lewis[1], Philippa Chandler[1], Karin Schianetz[1], Pascal Scherrer[2], Pierre Horwitz[2], Jeremy Northcote[2], David Newsome[3], Angus Morrison-Saunders[3]

[1]Curtin University of Technology
[2]Edith Cowan University
[3]Murdoch University
T.jones@curtin.edu.au

The twin goals of the Ningaloo Destination and Data Modelling (NDDM) project are: to develop a dynamic model of Ningaloo incorporating socio-economic, and load implications of tourism that can be integrated with an ecological model of the region; and to effectively engage with stakeholders to build both trust in the model and group learning between researchers and stakeholders with respect to regional tourism planning and governance. Drawing its methodology from mediated modelling, which developed within learning organisations theory, and sustainable tourism planning, the NDDM project is engaging with stakeholders through public workshops, meetings and disseminating information through newsletters and the regional media. The finished model will be used by regional managers (in particular DEC, DPI and the Shires) to input into land and resource use decisions and by all stakeholders including community groups, the shires and the tourism industry, to collaboratively assess and discuss tourism planning in the region. The NDDM project is gathering primary data through surveys of visitors, residents and accommodation providers, and is engaging with other research projects, industries, and public agencies to gather and share secondary data. To date, the three most significant research outcomes are: four collated tourism scenarios for the region; the results of initial visitors surveys; and an early prototype of the Ningaloo Destination Model, that assesses the effects of changing the visitor mix on activities and accommodation demand in different subregions.

Modelling recreational site choice for Ningaloo

Michael Burton, Atakelty Hailu, Jananee Raguragavan

School of Agricultural and Resource Economics, University of Western Australia
mburton@fnas.uwa.edu.au

Random Utility Models (RUMs) provide a mechanism for estimating the impact of environmental, social and economic factors on recreational site choice. These models provide the basis for estimating the impact on economic welfare of changes in management strategies and for simulating changes in site choices resulting from changes in site attributes and access conditions. We present results from a site choice model estimated at the state level using recreational fishing data. The presentation also provides a summary of survey data on fishing and non-fishing site choice conducted by the project in Ningaloo.

Modelling to Monitoring: Integrating Research and Management for Ningaloo Coast.

Jeff Dambacher

CSIRO Marine and Atmospheric Research, Hobart
Jeff.dambacher@csiro.au

This talk will present an overview of integrating research programs for sustainable tourism development for the Ningaloo coast, and a statistical framework for long term monitoring of marine and coastal resources.

Making Research Count: Underpinning good communications

Geoff Syme and Peta Dzidic

CSIRO Land and Water, Perth WA
Geoff.syme@csiro.au

As part of the Wealth from Oceans Flagship a small "Client Outreach" project has been established. The activities of this project are intended to ensure that the outputs of the Flagship research contribute seamlessly to the overall cluster effort and provide useful information for all key stakeholder groups. These groups include state government departments, regional managers, other researchers, industry and interest groups and the general public. In particular, it is considered that the qualitative and quantitative modelling can be assisted in developing "easy to use" tools for different educative and decision making tasks. The project has three components. The first is a pragmatic networking activity to establish critical communication paths between projects, critical pathways for the flow of information between user groups and the most efficient ways in which to join each network. This activity is being conducted in close liaison with the Department of Environment and Conservation's communication planning activities. The second activity is developing the theory of shared cognitions to establish the least transaction cost method to ensure effective research integration. The final activity is to progress understandings of lay theories of network energy flows to ensure that the visual representations of ecological systems are not functionally misinterpreted by users.

Communicating science

Sue McKenna and Kelly Waples

Department of Environment and Conservation, Western Australia
Sue.mckenna@dec.wa.gov.au

Broader awareness of the science currently underway at Ningaloo Marine Park depends on effective communication. The key goal in communication is to demonstrate to the government and other stakeholders that money invested in research at Ningaloo Marine Park has been well spent and has made a difference. Achieving this goal will rely on communication at several levels including:

- between scientists and resource managers in a way that will improve policy, planning and management decisions;
- within the science community so that research projects and programs are coordinated and integrated to maximize outcomes, and
- to the public and other stakeholders so that they may be aware of research outcomes and their value.

To facilitate communication at these different levels and ensure that our overall communication goal is met, a communication plan has been developed jointly between the DEC, CSIRO Wealth from Oceans Flagship: the Ningaloo Collaboration Cluster, AIMS and WAMSI. This plan identifies key messages and strategies which will assist in the integration of research at Ningaloo Marine Park and ensure that relevant outcomes are incorporated into management. This will enable us to achieve our goal of highlighting to government, and other stakeholders, that investment in research at Ningaloo has made a difference. However, the success of this communication plan, and of the Ningaloo Research Program, relies on our joint commitment to play our part in communicating science.

Long term trends in the Leeuwin Current and implications for marine ecosystem

Ming Feng

CSIRO Marine & Atmospheric Research
ming.feng@csiro.au

Enhanced surface warming in the Leeuwin Current has been observed during the past decades. The warming trend is greater during the austral winter than the austral summer. By analysing a 44-year eddy-resolving numerical simulation output, the heat budget in the Leeuwin Current region is found to be dominantly balanced by two terms, the Leeuwin Current heat advection and the air-sea heat loss, on the annual and interannual scales. From the 1960s to 1990s, the modelled Leeuwin Current has had a 30% reduction of its volume transport, likely driven by the weakening of the trade winds and related thermocline anomalies in the Pacific, which leads to a 20 W/m^2 reduction of heat advection into the region and causes a similar reduction of surface heat loss.

The Leeuwin Current is important to alongshore connectivity and cross-shelf transport along the west coast of WA. The Leeuwin Current and its eddy field also play a significant role in regional ocean production. Surface heat loss caused vertical mixing may be important in bringing nutrient into the euphotic zone. In WAMSI Node 2, research is underway to further quantify the trends in the Leeuwin Current system and understand their potential impacts on marine ecosystem. The project also plans to derive the future Leeuwin Current projection under different greenhouse emission scenarios.

Noughts and crosses management of natural marine assets in the Gascoyne Bioregion: ecosystems, marine parks, fisheries.

Dan Gaughan

Department of Fisheries, WA, Western Australian Fisheries and Marine Research Laboratories, 39 Northside Drive, Hillarys WA 6025
Daniel.gaughan@fish.wa.gov.au

The *Ningaloo Research Program* (NRP) was instigated through the efforts of *Department of Environment and Conservation* (DEC), and is now working through a large portfolio of focussed research programs (e.g. *WAMSI* and *CSIRO Wealth from Oceans* programs). Three high levels of management-concern are associated with the natural assets (1 for BSB) of the Ningaloo region. DEC are primarily concerned with managing the ecosystem (*sensu lato*, including biodiversity and ecosystem functioning) within the Ningaloo Marine Park. Thus, the NRP will develop a better understanding of the Ningaloo Marine Park so as to achieve better management. The Department of Fisheries (DOF) is likewise concerned with managing the ecosystem, but beyond the limits of marine parks. However, DOF has traditionally focussed on assessments of targeted species or management of particular fisheries, so has been seen to have a different focus from DEC. While DOF's current activities in the Ningaloo region do indeed focus on targeted species (e.g. spangled emperor, goldband snapper, Spanish mackerel) the overlap between (a) the whole-of-stock level of research undertaken by DOF and (b) the marine-park level research activities undertaken by/for DEC has promoted an enhanced cross-fertilization of research capacity as well as fostering an improved understanding of the explicit and implicit management goals. In turn, this has lead to better alignment of strategic directions, expected outcomes and research goals for conserving marine ecosystems. DOF and DEC have many similar foci, albeit on different spatial scales, so have benefited from the opportunities for co-operation presented by similar interests at Ningaloo.

Rapid assessment of scenario outcomes for natural resource management

Fabio Boschetti, Arnaud de La Tour, Beth Fulton & Rich Little

CSIRO Marine and Atmospheric Research, Floreat, WA
Fabio.Boschetti@csiro.au

We describe ScenarioLab, a tool to rapidly assess the impact of management decisions on fish populations under different scenarios. In this case the scenarios characterise the Ningaloo Marine Park. Each stage of the modelling process is controlled by graphic user interfaces which allow comparison of the outcomes of multiple runs of an ecological and management model and to decide what further modelling is needed.

At the core of this method lies the belief that the management program may not need to be set a priori, rather may emerge as a result of the interaction between different parties, which ScenarioLab may facilitate. We envisage that a team including managers and stakeholders (rather than a single expert user) may employ this approach as an avenue for communication, leading to exploration and discussion of the conflicting aspects of different model outcomes.

For this to be possible the tool needs to a) be intuitive enough to be comfortably controlled by non-expect modellers, b) run very fast so that the results can be computed in almost real-time, c) provide for a flexible way to define the suitability of a strategy outcome and d) allow modification of goals at any stage of the process, as a result of the information provided and the discussion it generated. All implementation and software design decisions have been made in order to accommodate the above points as main priorities. These are discussed in more detail below.

POSTERS

AND

ADDITIONAL ABSTRACTS

Note: This section includes additional abstracts that were not available at the time of the Symposium

Photo identification of manta rays in the Indo-Pacific Ocean

Florencia Cerruti

Charles Darwin University
florenciacp@gmail.com

Mark and recapture (or sight and resight) studies are one of the most prevalent and widely tested methods of estimating demographic parameters such as population size, survival, movement rate, and age/sex structure. This technique based in photo-identification uses signs, marks or scars present on the animals and which makes it less disruptive to the animal and their environment. Photo-id libraries from the Maldives, Ningaloo Reef, WA and Yap Islands are being used to study population parameters and migration of manta rays from Indo-Pacific Ocean. The aim of this study is to identify if there is a "typical" aggregation of manta rays where a specific size and /or sex is the most common. It's been identified that cleaning stations and feeding grounds are the most important aggregation sites in each location but how many mantas participate in it and why they are grouping in such places are some of the questions we intend to answer. With libraries with photos of several years, it is possible to determine residency of individuals and site fidelity which helps to understand the population dynamic and sexual-biased migrations. The understanding of their population traits and migration patterns is essential to 1) maintain the ecotourism industries that these rays support in hot spots like Ningaloo Reef, W.A. or Maldive Islands, and 2) to improve the local management plans and regulations. Moreover, the ongoing long-term project this study is part from will improve the general understanding of the manta rays movements through international waters, giving the possibility to design protected areas in international and shared waters.

An analysis of sex ratio of Western Australian Humpback Whales migrating past North West Cape, Western Australia, and implications for population size estimates

Jenner, K.C.S[1], Jenner M-N[1], Salgado Kent, C.P[2], Brasseru, M. [3]

[1]Centre for Whale Research (WA) Inc.
[2]Curtin University of Technology
[3]Edith Cowen University

The current recovery rate estimates of the population of humpback whales that migrate along the Western Australian coast every year is approximately 10%/yr. While past population size estimates are on the order of 8,000-14,000 (1999), the current size could be anywhere from 15,000 to 25,000 whales (50-100% of the estimated pre-whaling numbers). These values could represent underestimates, however, if in fact all whales do not make the annual migration. A sample of 258 whales biopsy sampled during 2002 and 2003 off North West Cape Western Australia resulted in male skewed sex ratios in both seasons. During preliminary analyses, no sampling biases (towards sampling more males than females) could be detected that could be explained by differences in cue type, month, year, pod size, migration speed, sea state, swell, and direction of migration. Given that measurements of sex ratio in the Antarctic have shown evidence of fairly equal sex ratios, this preliminary study so far supports the suggestion that a portion of the females may not migrate north to the breeding grounds each season. Further investigation is planned and required to confirm the findings presented here.

Loggerhead turtle (*Caretta caretta*) nest predation at Cape Range National Park

Sabrina Trocini, Stuart Bradley, Mandy O'Hara, Ian Robertson, Kristin Warren

Murdoch University
s.trocini@murdoch.edu.au

Most of the existing sea turtle populations worldwide are in decline. In particular, loggerhead turtles (*Caretta caretta*) are listed as endangered and loggerhead nesting populations in Eastern Australia have declined by 86% since the 1970s. However, whilst Eastern Australian loggerhead populations have been extensively studied and monitored, not much is known about the Western Australian nesting population.

This study aims to collect critical baseline data regarding nest ecology and hatching success of the loggerhead turtle nesting population in Cape Range National Park. The research was conducted for two nesting seasons (2006/07 and 2007/08) and initial results show that in Cape Range National Park nest predation is a crucial key factor affecting hatching success. Predation by ghost crabs (*Ocypode* spp), monitor lizards (*Varanus giganteus*) and feral European red foxes (*Vulpes vulpes*) considerably reduce survivorship from egg to hatchling. In fact, in the first and second years of this study, 76% and 80% of the monitored nests respectively, showed signs of partial or complete nest predation. The only introduced predator is the feral fox; however numbers of ghost crabs could have increased above normal levels due to tourism activities in Cape Range National Park.

This level of predation, coupled with other anthropogenic causes of decline at the foraging site and during migration to the nesting site (i.e. poaching, fisheries by-catch and pollution), is unlikely to be sustainable in the long term and more studies are recommended to identify successful management strategies to reduce nest predation on this beach.

In conclusion, this study takes an important first step towards obtaining crucial information on loggerhead turtle nest ecology and nest predator dynamics in this region; and will provide fundamental information for management policies and conservation initiatives aimed at conserving these sea turtle populations.

Spatial variation in herbivory on Ningaloo Reef

Vergés A[1], Hyndes G[1], Vanderklift M[2], Babcock R[3], Haywood M[3], Doropoulos C[1], Thomson D[2]

[1] Edith Cowan University, Centre for Marine Ecosystem Research, School of Natural Sciences. 100 Joondalup Drive, Joondalup 6027, WA
[2] CSIRO Marine Research Floreat, Private Bag No. 5, Wembley 6913, WA
[3] CSIRO Marine and Atmospheric Research, PO Box 120 Cleveland, QLD
a.verges@ecu.edu.au

Primary consumers play a crucial role in maintaining coral reef resilience by reducing the cover of macroalgae, which would otherwise out-compete corals. Since undisturbed coral reefs depend on particularly high levels of algal consumption to persist, it is essential to understand the quantitative nature of these algal-herbivore interactions for the successful management of these systems. However, the impact of algal consumers is not uniform across all habitats, and coral reefs may be viewed as spatial mosaics of adjoining animal- and macroalgal-dominated communities with contrasting levels of herbivory. In this study, we aim to quantify spatial variation in herbivory in the Ningaloo Marine Park using a combination of descriptive and experimental approaches. Herbivore abundance (fish and invertebrates) will be measured in three distinct habitats (lagoon, reef crest and outer reef). The relative impact of herbivores in each habitat will be determined using video-taped macroalgal tethering experiments. Preliminary results show important differences between habitats that diverge from patterns described in other coral reef systems. Additionally, the co-existence of tropical and temperate herbivorous fish in Ningaloo reef appear to result in unique algal-herbivore interactions, with some temperate fishes potentially exerting a disproportionate influence on macroalgal abundance.

Commercial and recreational fishing of demersal scalefish within the Ningaloo Marine Park and broader Gascoyne region.

Ross Marriott

Department of Fisheries WA, Western Australian Fisheries and Marine Research Laboratories, 39 Northside Drive, Hillarys WA 6025.
Ross.Marriott@fish.wa.gov.au

The Department of Fisheries WA is currently undertaking research on commercial and recreational fishing of demersal scalefish within the Ningaloo Marine Park and broader Gascoyne region for allocating fish resources between these sectors through the Integrated Fisheries Management (IFM) initiative within the broad context of Ecological Sustainable Development (ESD). Research projects are collecting information on current levels of fishing, catches, and the biology of key species caught in the Gascoyne Coast Bioregion (GCB), which includes the coastal and offshore waters of Shark Bay to Exmouth Gulf. The four IFM indicator species of primary focus in the GCB are: spangled emperor (*Lethrinus nebulosus*), Spanish mackerel (*Scomberomorus commerson*), pink snapper (*Pagrus auratus*) and goldband snapper (*Pristipomoides multidens*).

New research on spangled emperor has been focused on filling gaps in existing knowledge about its biology and to understand fishing impacts on its populations. This poster presents preliminary results, including evidence from Ningaloo Reef of pre-maturational sex change and estimates for the average size and age at which females mature.

A spatial and temporal framework for historical human usage data in the Ningaloo Marine Park

C. B. Smallwood, L. E Beckley and S.A Moore

School of Environmental Science, Murdoch University, South Street, Murdoch, 6150
c.smallwood@murdoch.edu.au

The investigation of human usage patterns in marine protected areas has not previously been a priority for conservation managers. However, increased visitation and impacts from the wide variety of recreational activities being undertaken, particularly in multiple-use marine parks, have highlighted the importance of monitoring these activities to ensure the sustainable use and future management of these areas. Ningaloo Reef is the largest fringing coral reef in Australia extending ~ 300km along the Western Australian coast. The Ningaloo Marine Park (NMP), originally gazetted in 1987, was extended southwards in 2004 to encompass the whole of this area. A wide variety of shore and boat-based recreational activities, such as fishing, SCUBA diving, snorkelling, kayaking and surfing, are known to occur in the NMP and camping is popular along the adjacent coastal strip. As part of the CSIRO Wealth from Oceans Ningaloo Collaboration Cluster, a project is underway to determine the spatial and temporal patterns of human usage in the NMP. To complement this current project, all available historical human use datasets relating to the NMP and adjacent coastal strip were collated and reviewed. These datasets include; long term monitoring of camping, vehicle counts, recreational fishing and boating surveys by relevant state government agencies, as well as various university managed projects investigating tourism. This information has been summarised to highlight the time periods for which these data exist, their spatial extent and key findings. Whilst these data provide an indication of activities in parts of the NMP during the specific project timeframes, few encompass the whole NMP and the collection of the majority of this information has been at a relatively coarse spatial scale. This review has highlighted the need for further collection of human usage data at appropriate temporal and spatial scales in order to provide decision support for the management of recreational activities in the NMP.

Robust, comparable population metrics through collaborative photo-monitoring of whale sharks *Rhincodon typus*

Jason Holmberg,[1,4] Bradley Norman,[2] And Zaven Arzoumanian[3]

[1]ECOCEAN, 4836 NE 31st Avenue, Portland, Oregon 92711 USA
[2]ECOCEAN, c/o Centre for Fish and Fisheries Research, Murdoch University, South Street, Murdoch, Western Australia 6150 Australia
[3]USRA, 10211 Wincopin Circle, Suite 620, Columbia, Maryland 21044 USA

The formulation of conservation policy for species that are rare and migratory requires broad cooperation to ensure that adequate levels of standardized data collection are achieved and that the results of local analyses are comparable. Estimates of apparent survival rate, relative change in abundance, and proportions of newly marked and returning individuals can inform local management decisions while highlighting corresponding changes at other linked research stations. We have applied computer-assisted photo-identification and mark–recapture population modeling to whale sharks *Rhincodon typus* at Ningaloo Marine Park (NMP), Western Australia, to create a baseline trend for comparison with other regional aggregations of the species. We estimate several ecological parameters of interest, including an average apparent survival rate of 0.55 yr_1 for sharks newly marked (new) and 0.83 yr_1for sharks captured in multiple seasons (philopatric). The average proportion of philopatric sharks is found to be 0.65 of the total population, and we derive an average population growth rate of 1.12 yr_1 for them. Our analysis uncovered significant heterogeneity in capture and survival probabilities in this study population; our chosen model structures and data analysis account for these influences and demonstrate a good overall fit to the time-series data. The results show good correspondence between capture probability and an available measure of recapture effort, suggesting that unmodeled systematic effects contribute insignificantly to the model fits. We find no evidence of a decline in the whale shark population at NMP, and our results provide metrics of value to their future management. Overall, our study suggests an effective approach to analyzing and modeling mark–recapture data for a rare species using computer-assisted photo-identification and opportunistic data collection from ecotourism to ensure the quality and volume of data required for population analysis.

Mark-recapture photo-identification in the third dimension

Bradley Norman,[1] Jason Holmberg,[2] and Seth Ladygo[2]

[1]ECOCEAN, c/o Centre for Fish and Fisheries Research, Murdoch University, South Street,
Murdoch, Western Australia 6150 Australia
[2]ECOCEAN, 4836 NE 31st Avenue, Portland, Oregon 92711 USA

Existing algorithms for computer-assisted photo-identification of whale sharks, such as the I3S and modified Groth algorithms, assume a two-dimensional surface for pattern recognition of spots and require a standard orientation of the photographer to that surface to maximize the capabilities of the algorithm. As photographic angle changes away from the perpendicular to this fiducial region of spots, the capabilities of the algorithms degrade as the interrelationships of spots are distorted. This presents a reduced chance of identification from photographs opportunistically collected from untrained divers and snorkellers who may not be able to capture fiducial region at the correct angle. Similarly, the short nature of whale shark interactions in some areas may not allow enough time for proper positioning of the camera to the shark, even for an experienced researcher.

We present the application of basic 3D modeling to wildlife mark-recapture. By mapping 2D photographs to a proportional 3D model of a whale shark, we demonstrate the ability to normalize the angle of a whale shark flank to maximize pattern recognition potential from photographs. The use of this open-source software tool will be of use to whale shark mark-recapture programs using opportunistic data collection from ecotourism to increase data uptake for population modeling.

A new prospect for tagging large free-swimming sharks; results from short-term data-logger deployments

Adrian C. Gleiss[1*], Brad Norman[2], Nikolai Liebsch[1], Rory P. Wilson[1] & Clive Francis[3]

[1] Institute of Environmental Sustainability, Biological Sciences, Swansea University, Singleton Park, SA1 8PP, UK
[2] ECOCEAN, Centre for Fish & Fisheries Research, Murdoch University, South Street, Murdoch, WA 6150, Australia
[3] School of Engineering, Swansea University, Singleton Park, SA1 8PP, UK

Sensor types in animal-attached remote-sensing (e.g. accelerometers, speed sensors and compasses) now require many tags to be solidly attached to an animals' body, rather than tethered, therefore precluding their use on many large species of shark. A new method of remotely attaching such tags to large sharks is presented which allows free-swimming animals to be equipped without any form of restraint. The system was tested on three free-swimming whale sharks (*Rhincodon typus*) at Ningaloo Reef, Western Australia. Devices were placed on one of two elongated arms emanating from a compression spring which acted to force the arms together. The system was clamped to the second dorsal fin using a specially-designed tagging-gun operated manually by a snorkeler. Each arm was equipped with two, 2 cm-long spikes, to ensure stable, firm attachment to the fin. Data from the deployments showed that a small shark (approx. 4m TL) exhibited a brief response after being equipped, while the larger sharks (approx. 6.5m and 8.5m) exhibited no apparent reaction to attachment. Clamps remained stable on the sharks during the time of observation. The whole system was fitted with a corroding magnesium link to ensure that the clamp would release within weeks.

NINGALOO RESEARCH

CONTACTS

NAME	ORGANISATIONS	EMAIL
Abraham, Irene	Murdoch University	l.mckissock@murdoch.edu.au
Ambrose, Jane	Department of Environment, Water, Heritage and the Arts	jane.ambrose@environment.gov.au
Anastasakis, Phil	Exmouth Shire	ceo@exmouth.wa.gov.au
Appleyard, Sharon	CSIRO	sharon.appleyard@csiro.au
Armstrong, Shannon	Department of Environment and Conservation WA	shannon.armstrong@dec.wa.gov.au
Babcock, Russ	CSIRO	russ.babcock@csiro.au
Bancroft, Kevin	Department of Environment and Conservation WA	kevin.bancroft@dec.wa.gov.au
Bates, Bryson	CSIRO	bryson.bates@csiro.au
Bathgate, Doug	Coral Coast Parks Advisory Committee	dbathgate@bigpond.com
Battershill, Chris	AIMS	c.battershill@aims.gov.au
Beaton, Rowena	University of Western Australia	beator01@student.uwa.edu.au
Beckley, Lynnath	Murdoch University	l.beckley@murdoch.edu.au
Black, Bob	University of Western Australia	rblack@cyllene.uwa.edu.au
Blake, Steve	Western Australian Marine Science Institute	steve.blake@wamsi.org.au
Boschetti, Fabio	CSIRO	Fabio.Boschetti@csiro.au
Bradshaw, Cory	Charles Darwin University	corey.bradshaw@cdu.edu.au
Brinkman, Richard	AIMS	r.brinkman@aims.gov.au
Bryce, Clay	WA Museum	Clay.Bryce@museum.wa.gov.au
Burridge, Chris	CSIRO	chris.burridge@csiro.au
Burton, Michael	University of Western Australia	mburton@fnas.uwa.edu.au
Caley, Julian	AIMS	j.caley@aims.gov.au
Caporn, Laurie	Department of Fisheries, WA	laurie.caporn@fish.wa.gov.au
Carroll, Garry	CSIRO	Gary.Carroll@csiro.au
Cary, Jennie	Department of Environment and Conservation WA	jennie.cary@dec.wa.gov.au
Catlin, James	Curtin University University	james.catlin@gmail.com

NAME	ORGANISATIONS	EMAIL
Ceh, Janja	Murdoch University	j.ceh@murdoch.edu.au
Cerutti, Florencia	Charles Darwin University	florenciacp@gmail.com
Chandler, Philippa	Curtin University	pippagirl@hotmail.com
Chapman, Kelly	Edith Cowan University	kelly.chapman@gmail.com
Chidlow , Justin	Department of Fisheries, WA	Justin.Chidlow@fish.wa.gov.au
Clapin, Geordie	CSIRO	geordie.clapin@csiro.au
Collins, Lindsay	Curtin University	L.Collins@curtin.edu.au
Coyle, Rebecca	Marine policy and planning	rebecca.coyle@dec.wa.gov.au
Crawford, Steve	Director Policy and Planning, Tourism WA	steve.crawford@westernaustralia.com
D'Adamo, Nick	Bureau of Meteorology	n.d'adamo@bom.gov.au
Dambacher, Jeff	CSIRO	Jeffrey.Dambacher@csiro.au
de la Mare, Bill	CSIRO	bill.delamare@csiro.au
Dekker, Arnold	CSIRO	arnold.dekker@csiro.au
Depczynski, Martial	AIMS	m.depczynski@aims.gov.au
Doherty, Peter	AIMS	p.doherty@aims.gov.au
Doropoulos, Christopher	Edith Cowan University	c.doropoulos@ecu.edu.au
Douglas, Kirsty	Department of Environment, Water, Heritage and the Arts	kirsty.douglas@environment.gov.au
Dzidic, Peta	CSIRO	peta.dzidic@csiro.au
Edwards, Luke	Bluenet	luke@ivec.org
Ellis, Richard	APPEA	rellis@appea.com.au
England, Phillip	CSIRO	phillip.england@csiro.au
Fearns, Peter	Curtin University	p.fearns@curtin.edu.au
Feng, Ming	CSIRO	ming.feng@csiro.au
Fitzpatrick, Ben	University of Western Australia	fitzpb02@student.uwa.edu.au
Fletcher, Rick	Department of Fisheries, WA	rick.fletcher@fish.wa.gov.au
Ford, Inday		indayford@hotmail.com

NAME	ORGANISATIONS	EMAIL
Foster, Taryn	Murdoch University	30398536@student.murdoch.edu.au
Fromont, Jane	WA Museum	jane.fromont@museum.wa.gov.au
Fulton, Beth	CSIRO	Beth.Fulton@csiro.au
Gaughan, Daniel	Department of Fisheries, WA	daniel.gaughan@fish.wa.gov.au
Gaynor, Andrea	University of Western Australia	agaynor@cyllene.uwa.edu.au
Gazzani, Flavio	Murdoch University	f.gazzani@murdoch.edu.au
Gilmour, James	AIMS	j.gilmour@aims.gov.au
Goater, Sarah	Water Corporation, Business Services Division	sarah.goater@watercorporation.com.au
Grafton, Quentin	Australian National University	quentin.grafton@anu.edu.au
Gray, Randall	CSIRO	randall.gray@csiro.au
Green, Peter	Ningaloo Research Centre Committee	pgreen@westnet.com.au
Green, Tim	Department of Fisheries, WA - Compliance	timothy.green@fish.wa.gov.au
Grubba, Tim	Woodside	tim.grubba@woodside.com.au
Hailu, Atakelty	University of Western Australia	ahailu@are.uwa.edu.au
Harcourt, Rob	Macquarie University	rharcour@gse.mq.edu.au
Harvey, Euan	University of Western Australia	euanh@cyllene.uwa.edu.au
Harvey, Matt	Murdoch University	matt@harves.net
Haywood, Mick	CSIRO	mick.haywood@csiro.au
Henry, Colleen	Department of Planning and Infrastructure, Ningaloo Sustainable Development Office	colleen.henry@dpi.wa.gov.au
Heyward, Andrew	AIMS	a.heyward@aims.gov.au
Hine, Jacqueline	Ningaloo Community	jacqueline.hine@bigpond.com
Hockey , Keith	Department of Environment and Conservation WA	keith.hockey@dec.wa.gov.au
Hodgson, Amanda	University of Queensland	hodgson.aj@gmail.com
Hollander, Edwina	CSIRO	edwina.hollander@csiro.au
Holley, Dave	Edith Cowan University	d.holley@ecu.edu.au
Horwitz, Pierre	Edith Cowan University	p.horwitz@ecu.edu.au

NAME	ORGANISATIONS	EMAIL
How, Jason	Edith Cowan University	j.how@ecu.edu.au
Hughes, Michael	Curtin University	Michael.Hughes@cbs.curtin.edu.au
Huisman, John	Murdoch University	J.Huisman@murdoch.edu.au
Humphries, Stuart	University of Sheffield	s.humphries@sheffield.ac.uk
Hyndes, Glenn	Edith Cowan University	g.hyndes@ecu.edu.au
Ingram, Colin	Department of Environment and Conservation WA	colin.ingram@dec.wa.gov.au
Irvine, Tenille	CSIRO	Tennille.Irvine@csiro.au
Jenner, Curt	Centre for Whale Research	curtjenner@telstra.com
Jones, Chris	Murdoch University	ignoblis@iinet.net.au
Jones, Tod	Curtin University	T.jones@curtin.edu.au
Keesing, John	CSIRO	John.keesing@csiro.au
Kendrick, Alan	Department of Environment and Conservation WA	alan.kendrick@dec.wa.gov.au
Kendrick, Peter	Department of Environment and Conservation WA	peter.kendrick@dec.wa.gov.au
Klonowski, Wojciech	Curtin University	wojciech.klonowski@postgrad.curtin.edu.au
Kobryn, Halina	Murdoch University	h.kobryn@murdoch.edu.au
Kompas, Tom	Australian National University	tom.kompas@anu.edu.au
Kuchling, Gerald	University of Western Australia	kuchling@cyllene.uwa.edu.au
Langdon, Mark	Murdoch University	mark-pam@bigpond.net.au
Last, Peter	CSIRO	peter.last@csiro.au
Lavery, Paul	Edith Cowan University	p.lavery@ecu.edu.au
Lawrie, Ray	Department of Environment and Conservation WA	ray.lawrie@dec.wa.gov.au
Lee, Sam	Curtin University University	sam.lee@curtin.edu.au
Lemmens, Sjaak	BHP Billiton	sjaak.lemmens@bhpbilliton.com
Lewis, Anna	Curtin University	annarlewis@hotmail.com
Little, Richard	CSIRO	Rich.Little@csiro.au
Loneragan, Neil	Murdoch University	n.loneragan@murdoch.edu.au

NAME	ORGANISATIONS	EMAIL
Lovelock, Cath	University of Queensland	c.lovelock@uq.edu.au
Lowe, Ryan	University of Western Australia	ryan.lowe@uwa.edu.au
Lynch, Merv	Curtin University	m.lynch@curtin.edu.au
Marriott, Ross	Department of Fisheries, WA	ross.marriott@fish.wa.gov.au
Marrs, Kimberley	Department of Environment, Arts, Water and Heritage FED	kmarrs@mac.com
Masini, Ray	Department of Environment and Conservation WA	ray.masini@dec.wa.gov.au
Mau, Roland	Department of Environment and Conservation WA	roland.mau@dec.wa.gov.au
McAllister, Fiona	AIMS	F.mcallister@aims.gov.au
McAuley, Rory	Department of Fisheries, WA	Rory.mcauley@fish.wa.gov.au
McCartney, Abbie	University of Western Australia	mccara01@student.uwa.edu.au
McCauley, Rob	Curtin University	r.mccauley@curtin.edu.au
McCulloch, Malcolm	Australian National University	malcolm.mcculloch@anu.edu.au
McDonald, David	CSIRO	david.mcdonald@csiro.au
McGhie, Doug	Science Matters Pty Ltd	doug@sciencematters.com.au
McGowan, Linda	Western Australian Marine Science Institute	linda.mcgowan@wamsi.org.au
McGregor, Frazer	Murdoch University	frazer_mcgregor@yahoo.com.au
McKenna, Sue	Department of Environment and Conservation WA	sue.mckenna@dec.wa.gov.au
McMahon, Kathryn	Edith Cowan University	k.mcmahon@ecu.edu.au
Meekan, Mark	AIMS	m.meekan@aims.gov.au
Melville-Smith, Roy	Department of Fisheries, WA	roy.melvillesmith@fish.wa.gov.au
Metcalf, Sarah	Department of Fisheries, WA	sarah.metcalf@fish.wa.gov.au
Mills, Des		desm3@iinet.net.au
Moore, Sue	Murdoch University	s.moore@murdoch.edu.au
Morrison-Saunders, Angus	Murdoch University	a.morrison-saunders@murdoch.edu.au
Murphy, Graham	President, Coral Bay Progress Association	kayakningaloo@bigpond.com
Newman, Stephen	Department of Fisheries, WA	stephen.newman@fish.wa.gov.au

NAME	ORGANISATIONS	EMAIL
Newsome, David	Murdoch University	D.Newsome@murdoch.edu.au
Norman, Brad	Ecoceans	brad@whaleshark.org
Northcote, Jeremy	Edith Cowan University	j.northcote@ecu.edu.au
Nowrojee, Rod	Department of Environment and Conservation WA	rod.nowrojee@dec.wa.gov.au
Pacioni, Carlo	Murdoch University	c.pacioni@murdoch.edu.au
Pandolfi, John	University of Queensland	j.pandolfi@cms.uq.edu.au
Parker, Justin	Geoscience Australia	justin.parker@ga.gov.au
Pattiaratchi, Charitha	University of Western Australia	chari.pattiaratchi@uwa.edu.au
Pember, Matt	Department of Fisheries, WA	matthew.pember@fish.wa.gov.au
Penny, Linda	Department of Industry and Resources	linda.penny@doir.wa.gov.au
Pinnel, Nicole	Murdoch University	n.pinnel@murdoch.edu.au
Polovina, Jeffrey	NOAA	jeffrey.polovina@noaa.gov
Prince, Bob	Scientist	bob.prince@dec.wa.gov.au
Raguragavan, Jananee	University of Western Australia	jananeer@cyllene.uwa.edu.au
Roberts, Rebecca	Murdoch University	r.roberts@murdoch.edu.au
Rodger, K	Murdoch University	k.rodger@murdoch.edu.au
Rogers, Peter	Western Australian Marine Science Institute	pprogers49@hotmail.com
Rogulsky, Kate	Marine Coastal Community Network	wa@mccn.org.au
Sainsbury, Keith	CSIRO	Keith.Sainsbury@csiro.au
Salgado, Chandra	Curtin University	c.salgado@cmst.curtin.edu.au
Samson, Cath	Department of Environment and Conservation WA	catherine.samson@dec.wa.gov.au
Scheffers, Anja	Southern Cross University	anja.scheffers@scu.edu.au
Schianetz, Karin	University of Queensland	karin.schianetz@uq.edu.au
Shaw, Jenny	Department of Fisheries, WA	jenny.shaw@fish.wa.gov.au
Simpson, Chris	Department of Environment and Conservation WA	Chris.simpson@dec.wa.gov.au
Skewes, Tim	CSIRO	Tim.skewes@csiro.au

NAME	ORGANISATIONS	EMAIL
Sleeman, Jai	Charles Darwin University	jai.sleeman@cdu.edu.au
Smallwood, Claire	Murdoch University	c.smallwood@murdoch.edu.au
Smith, Amanda	Department of Environment and Conservation WA	amanda.smith@dec.wa.gov.au
Smith, Leanne	Murdoch University	astraphobic@hotmail.com
Smith, Luke	Woodside	luke.smith@woodside.com.au
Speed, Conrad	Charles Darwin University	conrad.speed@cdu.edu.au
Spiers, Marissa	Department of Environment and Conservation WA	marissa.spiers@dec.wa.gov.au
Stanley , Fran	Department of Environment and Conservation WA	fran.stanley@dec.wa.gov.au
Steele, Wendy	CSIRO	wendy.steele@csiro.au
Stephenson, Lynne	Western Australian Marine Science Institute	lynne.stephenson@wamsi.org.au
Stevens, John D	CSIRO	john.d.stevens@csiro.au
Stewart, Brent	Hubbs-SeaWorld Research Institute	bstewart@hswri.org
Syme, Geoff	CSIRO	geoff.syme@csiro.au
Symonds, Graham	CSIRO	graham.symonds@csiro.au
Taebi, Soheila	University of Western Australia	taebi@sese.uwa.edu.au
Temple-Smith, David	Department of Planning and Infrastructure, Ningaloo Sustainable Development Office	david.temple-smith@dpi.wa.gov.au
Terry, Simon	Gascoyne Development Commission	gdcexmouth@westnet.com.au
Tomkins, Paula	Department of Environment, Water, Heritage and the Arts	paula.tomkins@environment.gov.au
Toranto, Tom	CSIRO	Tom.taranto@csiro.au
Trocini, Sabrina	Murdoch University	s.trocini@murdoch.edu.au
Twiggs, Emily	Curtin University	e.twiggs@curtin.edu.au
Underwood, Jim	University of Western Australia	underj01@student.uwa.edu.au
Usher, Kayley	University of Western Australia	kusher@cyllene.uwa.edu.au
Vanderklift, Mat	CSIRO	mat.vanderklift@csiro.au
vanKeulen, Mike	Murdoch University	keulen@murdoch.edu.au

NAME	ORGANISATIONS	EMAIL
Verges, Adriana	Edith Cowan University	a.verges@ecu.edu.au
Waite, Anya	University of Western Australia	waite@cwr.uwa.edu.au
Wang, Shao Feng	Chemistry Centre	Swang@ccwa.wa.gov.au
Waples, Kelly	Department of Environment and Conservation WA	Kelly.waples@dec.wa.gov.au
Warren, Kristin	Murdoch University	k.warren@murdoch.edu.au
Webb, Jason	Murdoch University	j.p.webb@murdoch.edu.au
Webster, Fiona	Murdoch University	F.Webster@murdoch.edu.au
Wells, Fred	Department of Fisheries, WA	fred.wells@fish.wa.gov.au
Wenziker, Krystal	Murdoch University	kristelw@bigpond.com
White, William	CSIRO	william.white@csiro.au
Williams, Alan	CSIRO	Alan.williams@csiro.au
Williams, Stefan	University of Sydney	stefanw@acfr.usyd.edu.au
Wilson, Emily	Department of Environment and Conservation WA	whale.shark@dec.wa.gov.au
Wilson, Kate	CSIRO	kate.wilson@csiro.au
Winfield, Vicki	Department of Environment and Conservation WA	vicki.winfield@dec.wa.gov.au
Wood, David	Curtin University	d.wood@curtin.edu.au
Woodley, Simon	AIMS	s.woodley@aims.gov.au
Wyatt, Alex	University of Western Australia	awyatt@graduate.uwa.edu.au