# WA Marine Science

# Show-and-Tell

# Seminar

**THURSDAY**
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# Marine science activities at CMST

**Dr Kim Klaka**
**Curtin University**

The Centre for Marine Science and Technology (CMST) at Curtin University comprises a multi-skilled body of scientists and engineers committed to research and development. Since its foundation in 1985, the Centre has earned a reputation as a group which responds quickly to industry and Government needs, producing the required outcomes on time and on budget.

The main fields of research are in:

- → Underwater acoustics and bio-acoustics
- → Marine geology
- → Underwater technology
- → Hydrodynamics
- → Satellite remote sensing
- → Ecotoxicology
- → Aquatic sciences

# DEC's Marine Science Program: Future Directions

**Chris Simpson**
**Program Leader, Marine Science Program, Science Division, Department of Environment and Conservation**

Marine science in Western Australia is in a period of rapid growth. Recent investment by the State Government, combined with co-investment from Commonwealth research agencies and local and interstate universities, will exceed $100M over the next five years. Much of this science is directly relevant to the objectives of the Department of Environment and Conservation (DEC). The Government has also substantially increased consolidated funding to implement the management plans of 'new' and existing marine protected areas, including significant specific allocations for marine research, monitoring, education/science communication.

The Marine Science Program (MSP) was established in the Science Division of the then Department of Conservation and Land Management in May 2006. The Science Division currently employs approximately 140 scientists and support staff spread over eight science 'Programs'.

The roles of the MSP are:

(i) *To conduct, or cause to be conducted, scientific research and monitoring programs necessary to manage existing marine parks and reserves; conserve marine biodiversity generally; assist in identifying and planning for new marine parks and reserves; and contribute to regional marine planning;*
(ii) *To provide policy advice to DEC Corporate Executive and the Minister for the Environment, and scientific and technical advice and support to DEC's regions and branches*;
(iii) *To provide a strategic focus for scientific and technical liaison with DEC's clients and stakeholders in relation to marine conservation; and*
(iv) *To assist the Marine Parks and Reserves Authority in the performance of its statutory duties as required*.

A Marine Science Strategy has been developed at the request of the Director General of DEC to provide a broad blueprint for the development and implementation of a marine science capability within DEC over the next five years[1]. The Strategy balances the need to influence, collaborate with and support external marine science providers with the need to develop an appropriate 'in-house' marine science capability. The 'in-house' capability is a partnership model based on the development of a centralised marine science capability within the MSP, based in the Science Division, and an operational capability in the Regions. The partnership also includes senior regional staff and key specialist branches within DEC including the Marine Policy and Planning Branch, Marine Ecosystems Branch, Environmental Management Branch and the Parks Policy and Service Branch. This general approach will ensure that the marine science capability is closely integrated with the marine policy, planning and management activities of the department.

The Strategy proposes the MSP be expanded to form a centralised group of scientists and support staff in three integrated units, a Marine Research Unit, a Marine Monitoring Unit and a Marine Science Communication Unit to support external and internal/collaborative research delivery and departmental marine monitoring, science communication, policy support and advisory functions. This group would, in collaboration with senior Regional staff and specialist branches, provide the technical oversight, co-ordination and implementation for DEC's marine science programs. Regional staff will provide the operational support for internal research and monitoring programs.

Initial priorities will focus on external research delivery (e.g. WAMSI Node 3), MPA management plan research, monitoring and science communication requirements and co-ordinating the research and monitoring of threatened marine fauna. The Strategy proposes that the science needs and capabilities for systematic surveys of WA's marine biodiversity, regional and MPA planning and marine environmental protection would be determined over the next year with the appropriate internal and external groups, all of whom have been consulted on this approach. A Marine Science Co-ordinating Committee will be established to ensure integration and co-ordination. The timeframe to implement the Strategy, if approved, and become fully operational would be 12-18 months.

[1] The Marine Science Strategy is currently being considered by the Director General of the DEC.

# Overview of WAMSI Node 4
# Sustainable Marine Ecosystems: ESD for the Marine State's Fisheries
# (*Implementing EBFM*)

**Rick Fletcher**
**Supervising Scientist, Stock Assessment and Data Analysis Branch**

**Department of Fisheries**
**WA Fisheries and Marine Research Laboratories, Hillarys**

The overall strategic purpose of this Node is to develop methods and/or generate the information needed to assist with the management of the marine ecosystems of Western Australia consistent with the principles of Ecologically Sustainable Development (ESD). Node 4 encompasses a diverse range of planned activities including investigation of a management system to implement ecosystem based fisheries management (EBFM), further development of ecosystem models for priority estuaries, investigation of community structure and biodiversity in WA's west coast region of WA and developing systems to monitor fisheries bycatch. Many aspects of this Node are currently being developed so as to address the priority fisheries management questions for WA.

# Fisheries Stock Assessment and Data Analysis in WA

**Dan Gaughan**
**Supervising Scientist, Stock Assessment and Data Analysis Branch**

**Department of Fisheries**
**WA Fisheries and Marine Research Laboratories, Hillarys**

The Stock Assessment and Data Analysis (SADA) Branch within the Research Division of the Department of Fisheries consists of the following sections

1. Statistics
2. Integrated monitoring and analysis
3. Population dynamics and databases
4. Information technology and communications
5. Library

Sections 1-3 provide direct support to research activities, while 4-5 provide crucial ancillary support.

Summaries of the research-related activities (1-3) are as follows.

Provide advice on, and undertake, statistical analyses and development of experimental design. Dedicated statisticians and their support staff provide a broad range of experience and skills to address any statistical problems and to deliver cutting-edge statistical techniques to other research projects.

Collection of catch and effort data from commercial, recreational and charter boat sectors is a key requirement for assessing the status of fisheries. The SADA Branch securely manages all these data, and has a key responsibility to meet the particular data requirements of each fisheries/projects in a consistent and repeatable manner. The quantity of data now being received has necessitated development of new databases and new ways of collecting data.

Fisheries management often uses formal mathematical models to simulate a natural fish population and how it interacts with fishing. Because such models are only a representation of reality they need to be carefully developed and then checked and rechecked, sometimes over a period of many years. The SADA Branch provides modelling expertise to a range of other research activities (e.g. western rock lobster, Shark Bay snapper). Training in model-development is routinely provided so in some cases the expertise for particular models now resides within individual fishery projects (e.g. shark models).

# Department of Fisheries: Biodiversity Branch

**Lynda Bellchambers**
**Principal Scientist, Biodiversity Branch**

**Department of Fisheries**
**WA Fisheries and Marine Research Laboratories, Hillarys**

DoF's Biodiversity Branch has the following projects

1. Ecosystem and Community Structure
2. Marine Mammals and Fisheries Interactions
3. Introduced Marine Pests
4. Marine Futures
5. Chemistry
6. Abrolhos Islands Research Institute (AIRI)

The Biodiversity section within the Research Division of the Department of Fisheries was established in 2006 to undertake research to underpin management of the State's biodiversity resources. The section is involved in a number of projects that are primarily aimed towards examining the effects of fishing and other activities on the marine environment.

The biodiversity section is currently largely externally funded (FRDC and NHT) and undertakes a suite of projects including the impact of fishing for rock lobster on the ecosystem, introduced marine pests, interactions of marine mammals and the efficiency of marine parks and sanctuary zones.

The role of the biodiversity section has become increasingly important with the implementation of Ecosystem Based Fisheries Management (EBFM), the increasing need within industry to:

1. Comply with regulations established by the Department of Environment and Water Resources
2. Move to towards industry-based certification i.e. Western Rock Lobster and the Marine Stewardship Council (MSC).

In addition the influx of funding, and general increase in public awareness, of Natural Resources Management (NRM) issues has meant that the section is now playing a pivotal role in the management of the states natural resources. In this area the section primarily undertakes research to evaluate the impact of policy decisions on biodiversity values i.e. Marine Park planning, introduced marine pests.

# Invertebrate Fisheries Research in WA

**Nick Caputi**
**Supervising Scientist (Invertebrate Branch)**

**Department of Fisheries**
**WA Fisheries and Marine Research Laboratories, Hillarys**

This talk will outline some examples of research being undertaken by the Invertebrate Branch for the stock assessment and management of commercial and recreational invertebrate fisheries in Western Australia. These fisheries include the western rock lobster; southern rock lobster; tiger, king and banana prawns in Shark Bay, Exmouth Gulf and other north-west locations; scallops in Shark Bay and Abrolhos Is.; greenlip, brownlip and roei abalone; pearl oyster; blue swimmer crabs in Shark Bay and lower west coast; deep sea crabs; and marron. There are also a number of minor and developing fisheries that include octopus, beche de mer, trochus, and mud crabs.

# Finfish Fisheries Research in WA

**Stephen Newman**
**Principal Scientist, Finfish Branch**

**Department of Fisheries**
**WA Fisheries and Marine Research Laboratories, Hillarys**

The Finfish Branch within the Research Division of the Department of Fisheries undertakes research to underpin management of the State's diverse finfish resources, and facilitates fisheries projects to support finfish research and environmental management. Finfish stocks studied include the West Australian dhufish, temperate snapper, tropical shallow and deep-water snappers, cods, emperors, sharks, pelagic stocks (pilchards, whitebait, mackerel), and coastal embayment and estuarine stocks (Australian herring and black bream). These finfish stocks are harvested by commercial fishers supplying local markets, the recreational fishing sector (involving in excess of 500,000 fishers), the managed recreational charter sector and indigenous fishers. Much of this research work relates to stocks that are the focus of the Department of Fisheries' Integrated Fisheries Management Strategy. The Finfish Branch also supports a significant proportion of the Research Division's external projects involving universities and other research agencies. These collaborative projects involve a considerable number of postgraduate research students.

DoF's Finfish Branch consists of the following projects:

1. Pelagic finfish sustainability – pilchards and mackerel
2. Shark and Ray sustainability – temperate and tropical shark fisheries
3. North coast demersal finfish sustainability – Kimberley and Pilbara trap, line and trawl fisheries
4. North coast inshore finfish sustainability – barramundi, threadfin salmon, silver cobbler
5. Gascoyne demersal finfish sustainability – assessment of key indicator species for IFM
6. Gascoyne inshore finfish sustainability – inner Gulfs of Shark Bay
7. West Coast demersal finfish sustainability – assessment of key indicator species for IFM
8. South Coast demersal finfish sustainability – developmental project
9. South/West Coast inshore finfish sustainability – RAP, fish kills, herring, tailor

# Internal waves on the North West Shelf

**Professor Greg Ivey**
**School of Environmental Systems Engineering (SESE)**
**University of Western Australia**

The North West Shelf (NWS) of Western Australia has some of the largest surface tides in the world, it has a shelf/slope bottom topography with a broad gently shelving continental shelf and, due to the lack of freshwater input and strong heating in the region, has a persistent and strong vertical temperature and hence density stratification. The combination of these effects creates one of the most energetic internal wave environments known anywhere, and the region is also home to the very large offshore oil and gas industry. A research program is currently under way to understand the mechanism associated with the generation, propagation and dissipation of these very large amplitude internal waves, the dominant feature of the physical oceanographic environment of the NWS. The program involves an integration of laboratory and theoretical development, direct measurements in the field and nested numerical modelling all designed to give process understanding and predictive capability of processes in the region.

# WAIMOS – West Australian Integrated Marine Observation System

**Charitha Pattiaratchi**

**School of Environmental Systems Engineering,**
**The University of Western Australia,**

The National Collaborative Research Infrastructure Scheme (NCRIS) allocated a total of total of $50 million, over 4.5 years has been allocated to develop an Integrated Marine Observation System (IMOS) for Australia. IMOS consists of a number of regional nodes which are supported by facilities specialising in the deployment of different instrumentation to provide data streams for marine research. The West Australian Integrated Marine Observing System (WAIMOS) is the WA component of IMOS with a concentration of measurements along the continental shelf and slope region between Jurien Bay and Cape Peron. This also includes the establishment of 3 Long Term Time Series Reference Stations (LTTSRS) at Dampier, Rottnest Island and Esperance. An emphasis is made on the multi-disciplinary real-time data to allow the development of each discipline, their integration and assimilation.

The proposed observation system is comprised of a number of innovative platforms to obtain real-time observations:

- surface currents using shore-based HF radar;
- vertical profiles of temperature, salinity, fluorescence, dissolved oxygen and water clarity using autonomous ocean gliders;
- time series moorings for currents, temperature, salinity, chlorophyll and turbidity
- passive acoustic sensors to monitor marine animals (fish and whales) in the Perth Canyon region
- Shipborne observations to compliment above.
- High resolution satellite data

The proposed observing system will greatly enhance the research programs undertaken by WAMSI participants which includes all of the WA Universities, State Government Agencies and the CSIRO Division of Marine and Atmospheric Research.

An overview of WAIMOS and deployment plans of instruments will be presented.

# SERPENT - Scientific and Environmental ROV Partnership using Existing industrial Technology

**Charitha Pattiaratchi (on behalf of the SEA-SERPENT Team)**

**School of Environmental Systems Engineering,**
**The University of Western Australia**

SERPENT is an international project which in collaboration with oil and gas industry aim to utilizes ROV technology to undertake deep-sea research. The SEA-SERPENT project, funded through an ARC Linkage grant is the South-East Asian component of SERPENT includes the Universities of Sydney, Western Australia, Wollongong and The University of Technology Sydney together with Woodside, Santos and Chevron.

The aim of SEA-SERPENT is to develop fundamental deep-sea science that will underpin environmentally sustainable drilling practices through:

1. Quantifying the effects of deep-sea drilling on benthic biodiversity;
2. Conducting field experiments to determine the mechanisms underlying the short- and long-term effects of the drilling disturbances on individual deep-sea fauna at the physiological level; and
3. Determining whether and to what extent sub-sea structures can create reefs in the deep sea

The project will take place on Australia's North West (NW) Shelf and Bass Strait which contain some of the largest ocean petroleum and gas reserves in the world. While Australia has no access to manned submersibles, the petroleum and gas industry increasingly uses ROVs for sub-sea intervention and through the SEA-SERPENT project we will have access to ROVs to explore Australia's deep-sea benthos for the first time. Understanding the intricate biodiversity of the deep-sea benthos and the complex interactions between it and deep-sea structures will be a major step in developing industrial practices and technologies that protect deep-sea ecosystems in the vicinity of structures.

The project is led by Dr Adele Pile (University of Sydney) a marine ecologist specialising in invertebrates. Other members include Professor Chari Pattiaratchi (The University of Western Australia), who will take responsibility for aspects that relate to characterising the physical oceanography of the deep sea; Professor Dave Booth (University of Technology Sydney), a marine ecologist specialising in fish, and will oversee aspects that relate to fish biodiversity and will lead the research team that will quantify the rigs to reef processes. Dr Murray Thomson (University of Sydney), an animal physiologist, will direct aspects of the measurements of physiological stress in deep-sea fauna and Dr Danielle Skropeta (University of Wollongong), an organic chemist, will oversee aspects related to measuring the chemical biodiversity of deep-sea fauna. Both Woodside and Santos are committed to the training of qualified scientists at all levels. The project will include a postdoctoral Research Associate, 3 PhD scholarships and 5 Honours scholarships each year.

# Cross-shelf transport induced by meso-scale eddies of the Leeuwin Current: Implications for the larvae of neritic biota.

**David Holliday**
**Ph.D. Candidate**
**Marine Management Research Group**
**School of Environmental Science**
**Murdoch University**

Leeuwin Current (LC) dynamics are known to influence regional fisheries production in Western Australia yet the exact mechanisms remain unclear. Meso-scale eddies of the LC may be an important process influencing the transport of planktonic larvae, in turn driving observed variability in marine populations. As part of a 25-day multi-discipline research voyage ('Eddies 06') investigating the biophysical dynamics of meso-scale eddies of the LC, data were collected with which to determine the implications of eddy–induced cross-shelf transport of finfish and invertebrate larvae, (e.g. Western Rock Lobster), and to assess the role of eddies in driving recruitment variability for the region. I will present circulation patterns determined from drifter trajectories, spatial distributions of fish larvae concentrations and the vertical stratification of fish larvae.

# Summer physical processes in the south of the Western Australian continental shelf

**M.A Fadzil , C. Pattiaratchi**
**School of Environmental System Engineering,**
**University Of Western Australia, Crawley 6009 WA, Australia**

The circulation on the southern Western Australian shelf was documented from recent voyage data. The field site covered the area between Cape Leeuwin (34.5°S, 115°E) and Twilight Cove (32.5°S, 126 °E ). CTD and ADCP data collected in April 2006 were used extensively to provide a better understanding of the summer surface circulation patterns along the south of the Western Australian continental shelf; this area is poorly understood with little available field data. There are two main current systems in the region: the Leeuwin current (LC) and the Flinders current (FC). The LC is established in the north-west, travels south, and turns into the Great Australian Bight (GAB). The FC flows opposite (offshore) to the LC. Part of the FC serves as an undercurrent of the LC, which imitates the Leeuwin undercurrent (LU). The characteristics of the LC flowing from west to east were the primary concern of this study. The behaviour, current pace, and water masses of the LC change along the southern coast. High salinity water entrained from the West Australian current into the region changes the LC characteristics as the LC reaches the south coast. Meanwhile, the LC's speed increases as it turns into the GAB; this intensity remains as it moves eastward. The FC is much dominant (offshore) current system in the south. By comparison, the undercurrent flowing beneath the LC in the south is much faster and travels at greater depths. This study showed that certain characteristics of the LC in the south differed from those of the LC observed along the west coast.

# Physical Oceanography of the Ningaloo Marine Park – Lagoon and Reef Circulation

**Graham Symonds, CSIRO Marine and Atmospheric Research**
**Richard Brinkman, AIMS**
**Chari Pattiaratchi, UWA**
**Ryan Lowe, Research Fellow, UWA**

A measurement program to quantify the wave, wind and tidally driven exchange between the Ningaloo lagoon and offshore was undertaken as part of the Ningaloo start-up projects. These data are being used in developing a hydrodynamic model of the Ningaloo region as part of WAMSI Node 3, Project 5. The field work was carried out from the AIMS research vessel Cape Ferguson over two cruises in 2006, April 10-17 and May 22-30, as part of a collaborative research effort involving research staff from AIMS, CMAR and UWA.

Anticipating that wave forcing would be dominant, with onshore flow over the reef crest and offshore flow through channels in the reef, the study site was centred on a channel in the region of Sandy Bay towards the northern end of the Ningaloo Marine Park. A large array of instruments including ADCP's, single point current meters, wave and tide gauges, were deployed across the channel, along the reef crest north and south of the channel, within the lagoon and offshore. Detailed analysis of these data will be undertaken in Project 3.5 but preliminary analysis clearly show onshore flow over the reef crest and offshore flow through the channel. Knowing the cross-reef volume transport of water, the length of the reef crest, and the volume of the lagoon derived from measured bathymetry, we have estimated the flushing time of the northern and southern lagoons in the study area to be 5.3 and 8.4 hours respectively.

# Hydrodynamic modelling of Ningaloo Reef

**Ryan Lowe, UWA**
**Chari Pattiaratchi, UWA**
**Graham Symonds, CSIRO Marine and Atmospheric Research**
**Richard Brinkman, AIMS**
**Greg Ivey, UWA**

We are developing a circulation model of the Ningaloo system as part of WAMSI Node 3, Project 5. The circulation of Ningaloo Reef is known to be a complex function of its bathymetry and the forcing conditions present. We are applying a 3D circulation model iteratively-coupled to a numerical wave model to predict how waves, tides, winds and buoyancy control the circulation and distribution of wave energy on Ningaloo Reef. Initially, we will apply the model to a test section of reef surrounding Sandy Bay, using field data collected during a April-May 2006 experiment to validate the model. By running simulations in parallel, we will eventually expand the model domain to incorporate large expanses of the reef system. This working circulation model will provide insight into how various ecological processes operating in Ningaloo Reef are coupled to hydrodynamics (e.g. recruitment, nutrient dynamics), and will provide a foundation for conducting a risk analysis of processes that may threaten its integrity (e.g. contaminant spills).

# Impact of climate variability and climate change on coastal marine ecosystem

**Ming Feng**
**CSIRO Marine & Atmospheric Research**

The pelagic ecosystem on the continental shelf off of west coast of Western Australia can be divided into two sectors according different physical forcings: north of Shark Bay, an austral summer bloom is driven by upwelling favourable winds; south of Shark Bay, there is a late autumn – early winter bloom, likely driven by the enhancement of the Leeuwin Current and eddy field and the arrival of winter storms. The total primary production on the shelf (pelagic and benthic) is 111.3 gC $m^{-2}year^{-1}$, or $1.1\times10^{7}$ tonne C $year^{-1}$. To support this annual production on the shelf, new nitrogen is derived from advection by the Leeuwin Current and its eddy field (8%) and seasonal upwelling (7%) from very preliminary estimates. It is estimated that 84% of the primary production is recycled on the shelf so that benthic-pelagic coupling is also a key process in the coastal ecosystem. During an El Niño year, the Leeuwin Current and its eddy field are weaker while the nitricline depth is shallower; during a La Nina year, the Leeuwin Current and its eddy field are stronger and the nitricline depth is deeper. Some of the interannual variations of the winter storm activity are also related to ENSO. In WAMSI we plan to quantify the climate variability in these physical forcings of the coastal ecosystem, as well as to understand the future changes in the physical forcings in the climate change scenarios. In collaboration with observational oceanographers, biologists, and biogeochemical modellers, progresses will also be made on the sensitivity of the coastal ecosystem to the climate variability and climate change.

# Current activities and "Human usage at Ningaloo" project

**Lynnath Beckley (Murdoch University)**

The Marine Management Research Group, comprising staff and post-graduates based in the School of Environmental Science at Murdoch University, has strong links with the Marine Science teaching programme and the Centre for Fish and Fisheries Research at the university. Our research covers biological oceanography, remote sensing in the coastal zone, human use of marine resources and marine protected areas. Our research is often applied in nature and provides scientific support for coastal management, fisheries management and conservation planning.

Our current biological oceanography work is focussed on the Leeuwin current and its eddies, in particular, larval fish assemblages and cross-shelf transport induced by meso-scale eddies. The remote sensing work is concentrating on the use of satellite imagery for monitoring and change detection in the coastal zone as well as the use of hyperspectral imagery for broad-scale mapping of shallow, coastal habitats (e.g. Rottnest Island Reserve and Ningaloo Marine Park). Work on human usage currently relates largely to recreational activities and builds on creel surveys of recreational fishing and concurrent mapping of human use at Rottnest Island and the Blackwood estuary.

The Wealth from Oceans Ningaloo Collaboration Cluster has provided an opportunity to undertake spatial mapping of human use at Ningaloo Marine Park. In 2007, an intensive field programme is underway that involves aerial surveys, coastal surveys along the length of the park and interviews with people engaged in recreational activities in the park (e.g. fishing, snorkelling, diving, kayaking etc). We aim to build spatial layers of human usage that can be included in the Ningaloo GIS and then examine the influence of access points, biodiversity, zoning, etc in relation to the spatial and temporal distribution of human use at Ningaloo. These data will be also used as inputs for systematic conservation planning software like MARXAN and CPLAN.

# SPICE and Education : What is being taught in School Marine Science

**Mark Lehmann**
**Padbury Senior High School / University of Western Australia**

Teaching Marine Science in schools has never been more interesting. More and more schools are seeing this as an exciting, innovative and interesting context to teach some of the new Upper School Science Courses. These courses provide for involvement in a number of areas, especially the Biological Sciences.

New courses have been developed through the Curriculum Council that, as the media has made quite clear, are going through some final changes. They will however allow some excellent Science to be taught, and hopefully increase the quality and numbers of future Marine Scientists. The courses are those of Biological Sciences, Integrated Science and the Australian first Marine & Maritime Technology. All of these have suggested marine contexts, recognising the interest of students in these areas.

Some schools have taken this further, and offer full marine studies courses. These schools include, but are not limited to, Padbury Senior High School, Rockingham Senior High School, South Fremantle Senior High School, St Marys, and PLC. These provide students increased exposure to the work of scientists as well as vocational training in other areas.

SPICE is a joint initiative between UWA and Department of Education and Training that has teachers taking on resource development for periods of time and thus allowing involvement in meaningful real world science and developing ways of informing other teachers of current research. Currently a resource is being developed to incorporate Marine Futures research into use for students as IT based transect analysis. This, and future resources, will provide exciting involvement of marine science into classes.

At Padbury Senior High School, the Marine Science course runs from years eight to twelve. In year eight students are introduced to Marine Studies and Marine Environment care through Project AWARE. In years nine and 10, they can elect to research, as an elective, various aspects of marine science. Negotiations are being developed into having students assist with research in Fisheries. Currently students in years 11 and 12 carry interest into the Senior Science course, but as the new courses come online, this will change. In all years, students also have the ability to gain a SCUBA certificate, and travel, to view places such as Busselton, the Abrolhos islands, Exmouth and this year to Vanuatu. Teaching Marine Science in schools has never been more interesting!

# Long term studies of population and community structure on intertidal rock platforms at Rottnest Island

**Jane Prince and Robert Black**
**School of Animal Biology, University of Western Australia**

Most ecological studies are conducted over short time periods relative to the generation time of the organisms being studied. To fully understand variation over relevant temporal scales, longer term studies that document patterns of distribution and abundance, recruitment, survival and growth are required. Our studies focus on the macroinvertebrate fauna of the rocky intertidal shores at Rottnest Island and encompass individual, population and community level analyses of data collected over 10 to 30 years comparing patterns between years and among and within rocky shores.

# Benchmarking the marine environment of the Capes

**Mark Westera, Euan Harvey and Gary Kendrick**
**School of Plant Biology, University of Western Australia**

The South West of WA is experiencing unprecedented tourism and population growth which may lead to increased pressure on the marine environment from coastal development, resource extraction or run-off from the land. To detect the effects of these activities marine benchmarks are required that determine the abundance, biomass and sizes of key organisms such as fishes, algae and invertebrates. A marine reserve is also proposed for the region which will include sanctuary zones for the conservation of biodiversity.

We implemented a before-after-control-impact (BACIP) design study in the Capes region to collect data on marine biota from reefs. This data and our ongoing monitoring will serve to set a benchmark against which future change could be gauged, in addition to assessing the potential effects of sanctuary zoning on biodiversity. Data on fishes, algae and invertebrates were collected from 21 locations using underwater videography and other techniques.

The results show a diverse marine environment, likely due to the influence of the Leeuwin and Capes currents that pass the region. One year into the project we have recorded 71 species of fishes, 221 species of algae and 30 species of mobile invertebrates. The fishes included targeted species such as blue groper, dhufish and queen snapper. The most common fishes were small wrasses. Algal communities were dominated by kelps and other brown algae with a diverse understorey. Invertebrates consisted mainly of seastars, urchins, and gastropods.

This is one of few studies to test the effects of marine reserves, using this design. Most other studies have been restricted to comparisons between fished and unfished areas once a marine reserve is implemented. Future sampling will build on the existing dataset and, over time, enable detection of changes in marine communities in the Capes region and an assessment of the effectiveness of sanctuary zones for biodiversity conservation.

This project was funded by the Natural Heritage Trust (NHT) which is a joint initiative of the State and Australian Government, and is administered by the South West Catchments Council.

# From geographical maps to ecologically relevant probabilistic maps of substratum and biota

**Gary Kendrick, Kimberly Van Neil, Karen Holmes, Euan Harvey, Ben Radford, Paul Kennedy, Neil Blake, Heather Taylor, Jane Fromont, Lynda Bellchambers, Des Lord and, Jessica Meeuwig.**

Securing WAs Marine Futures is a Natural Heritage Trust II statewide project setting the benchmark for ecological and management relevant mapping of marine resources in targeted areas of Western Australia. It is the latest multidisciplinary project from a team of researchers centered at the University of Western Australia in the Schools of Plant Biology and Earth and Geographical Science, but also including industry partners (FUGRO), State and Australian government departments (DEC, Fisheries WA, WA Museum, DPI, DEW) and regional NRM councils (SCRIPT, SWCC, SWAN, NACC and RANGELANDS). Previous projects laying the groundwork for MF have included :Parks Victoria, NSW Parks and Wildlife) and other research institutions (Curtin University, Deakin University, TAFI). This talk will present the history of development of the MF partnership through early projects to the present WA Marine Futures project, focusing on the importance of collaboration for success and implementation of research products by resource managers.

# Seagrass research at the University of Western Australia.

**Marion Cambridge, Gary Kendrick**
**School of Plant Biology, University of Western Australia**

Seagrasses form the basis of productive nearshore marine ecosystems in Australia but major losses have occurred due to coastal development and pollution. Almost one third of the world's seagrass species occur in south-western Australia, and these seagrass communities play a major role in the marine ecology, with benthic primary production from seagrasses and algae supporting detrital food webs. Recently, it has been proposed to restore seagrass habitats by transplanting meadow-forming seagrasses. These species are, however, large and slow growing, and rehabilitation programs have had only partial success, despite the large capital investment, highlighting the need for understanding the growth characteristics of the target species and their ability to survive and flourish in different habitats. A major focus of seagrass research at the University of Western Australia has been an ARC Linkage-funded study of growth of transplanted seagrass in the Albany Harbours. An extensive field program is providing detailed data on rhizome and shoot characteristics, and spreading rates of transplanted seagrasses which the aim of developing a modelling package that can be used to predict rates of seagrass spread from rehabilitation scenarios. Other projects include documenting rates of seagrass seedling recruitment, survival and growth, development of culture techniques for seedlings as transplant units, and population genetics of meadow-forming species to ensure appropriate genetic diversity of transplanted meadows. The long term goal is to develop broad-scale mechanical planting.

Regional mapping of seagrass habitats to document distribution and long-term changes in seagrass communities in south-western Australia began almost a decade ago and continues to expand with increasing emphasis on defining marine protection areas and the need to expand our understanding of shallow-water environments and processes.

# Establishing benchmarks of seagrass and water quality In Geographe Bay, Western Australia

***Mark Westera, Peter Barnes and Gary Kendrick***
**School of Plant Biology, University of Western Australia**

The University of Western Australia (UWA) have commenced a large scale study of the ecology of seagrasses in Geographe Bay. The aim of this work is to set a benchmark of seagrass health and water quality for Geographe Bay so that any impacts of population growth on seagrasses can be detected and minimised. Historical information from other studies will also be used to assess the past extent and condition of the seagrass meadows of Geographe Bay. With high population and tourist growth forecast for the SW region there is a potential for increased stress on the seagrass meadows. This may arise from coastal and industrial development or commercial and recreational activities. Greater summer rainfall is also predicted for the region, due to climate change, which may affect the flow of drains and rivers to the marine environment and consequently the seagrass meadows.

We are measuring the species composition of seagrass communities, the number of shoots per area and biomass of seagrass, as well as epiphytic algal communities that grow on seagrass leaves. Water quality samples are being collected to determine the levels of nutrients that may be entering Geographe Bay from drains and rivers or via the water table. We are also investigating the links between possible nutrient inputs and elevated growth of epiphytes on seagrass leaves. The growth of some types of epiphytes may shade seagrass leaves reducing their ability to photosynthesise and affecting their long-term health. In other parts of Australia excessive algal growth on seagrass leaves has led to significant loss of seagrass meadows.

A variety of data collection techniques are being used including video of the seafloor, visual counts of invertebrates and collecting seagrass for analyses in the laboratory. Baited underwater video is also being used to record the numbers and size of fishes in the seagrass meadows and their relationship with the habitat. The bay is dominated by *Posidonia sinuosa*, *Amphibolis antarctica* and *Amphibolis griffithii*. We have currently identified over 70 fish species and 80 invertebrate species. The most common fishes are leatherjackets, herrings, trevallies, wrasses and trumpeters however we have also recorded hammerhead and Port Jackson sharks, fiddler rays and stingrays, samson fish and juvenile pink snapper. The invertebrates are equally diverse with sponges and seasquirts being common and many species of sea cucumbers, crustaceans, corals, marine snails and bivalves. Squid are also common. The Leeuwin current is likely to influence the marine biodiversity of the region by bringing warm waters from the north in autumn and winter.

Between 1954 and 1976 seagrass cover declined at some locations in Geographe Bay. Nutrients have also been increasing in the marine system. Future sampling as part of the current project will build a comprehensive picture of the status of seagrass communities in Geographe Bay, including fishes and invertebrates, and whether they change from year to year. Data from the project, and comparisons with past studies, will determine whether terrestrial runoff is affecting seagrass meadows and contribute toward setting targets for acceptable levels of nutrient inputs.

This project was funded by the Natural Heritage Trust (NHT) which is a joint initiative of the State and Australian Government, and is administered by the South West Catchments Council.

# Cockburn Sound Management Council: Call for improved links to applied research and focussed monitoring - A partner waiting to happen

**Tom Rose**
**Coordinator – Cockburn Sound Management Council**
**Principal Environmental Officer**

The Cockburn Sound Management Council (CSMC) was established in 2000 and is responsible for ensuring the environmental values of Cockburn Sound and Owen Anchorage, a $10-12 billion economic asset, are protected. The 23 member council does this by implementing the State Environmental (Cockburn Sound) Policy 2005 and coordinating environmental planning and management of the Sound, its foreshores and catchment. Aside from developing a multiple use framework for its waters and foreshores, it also coordinates research and investigations and monitors and reports on performance in protecting the Sound. For example, it has annual report cards and must produce an annual report to Parliament on the State of the Sound.

The CSMC has a general research and investigations plan as outlined in its Environmental Management Plan (2005). This has identified major gaps in knowledge that would help better manage and protect the marine embayment. For example, major gaps in knowledge still exist on aspects of physical and hydrodynamic processes that affect currents and stratification, despite recent modelling and validation monitoring. There are also gaps in understanding biological processes such as those affecting phytoplankton succession and nutrient limitation, lack of quantifiable data on fish and benthic standing crops, spawning areas, trophodynamics, pollution effects along the eastern shelf (turbidity, thermal) and habitat characteristics that attract spawning or feeding. Other major gaps exist in understanding any risk that may be posed by emerging contaminants of concern or catchment processes such as for groundwater nutrient fluxes and the changing nature of surface water inputs. In turn these examples are influenced by mega-scale climate change and the unknowns associated with this long-term influence. Further gaps also exist in socio-economic factors affecting use and governance of the system.

To meet these challenges and address the gaps, the CSMC has a small budget to encourage research. Importantly, depending on the relevance of the proposal, it can be a partner and reference for research parties seeking external funding. We can be an influential ally to help encourage relevant research on coastal systems.

# Current research in fish ecology at The University of Western Australia

**Marine Ecology Group**
**School of Plant Biology**
**Faculty of Natural and Agricultural Sciences**

The Marine Ecology Group in the School of Plant Biology at The University of Western Australia has three full time academic staff, five research-only staff, seven technical and support staff and fifteen postgraduate students of which of which thirteen staff and students have active research in fish ecology. Research is being conducted over a broad geographic range spanning the Kimberly's in the north to sites east of the Recherché Archipelago in the south, NSW, Victoria and South Australia. Fisheries research topics include; benchmarking marine ecosystems, effects of fishing and protection, climate change impacts on distribution, grazing processes, spatial predictive modeling, habitat-fish assemblage links, fish assemblage dynamics and processes, and the development of fishery independent non-destructive sampling techniques. Techniques used by researchers at UWA to study aspects of fish ecology include; SCUBA diver surveys, diver-operated stereo-video, baited remote stereo-video, towed video, drift video, benthic cameras and cameras in trawls. The ultimate goal of research in fish ecology at UWA is an improved knowledge and understanding of processes and impacts that influence the structure and distribution of fish assemblages.

# Coastal water habitat mapping using acoustics

**A.N. Gavrilov, J.D. Penrose, P.J.W. Siwabessy, I.M. Parnum, and R.D. McCauley**
**Centre for Marine Science and Technology, Curtin University of Technology**

A vast coastal shelf of Western Australia contains a high diversity of marine habitats that require regular and hence cost-effective assessment in order to predict possible climatic and anthropogenic impacts and to effectively plan and manage in-shore and offshore development. As part of the Coastal Water Habitat Mapping project of the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, the Centre for Marine Science and Technology at Curtin University of Technology has developed methods for observation, mapping and classification of seafloor habitats in the coastal zones using sonar systems. Several shallow water regions along the western, southern and eastern Australian coasts have been surveyed using multi and single beam echo sounders. Acoustic observations were ground-truthed by stereo photography, video recordings and grab and core samples. A new method for deriving backscatter imagery of the seafloor has been elaborated for the state-of-the-art high-resolution multibeam sonar systems and implemented in a new software toolbox. The multibeam data processing technique developed in the project is capable of distinguishing different habitats, such as sand, rock, reefs, tropical and temperate ocean seagrass, rhodolith aggregations and some others, and mapping those on the seafloor using a mutual analysis of fine bathymetry and acoustic backscatter data supported with sparse ground-truthing observations. The method and toolbox are employed by several research groups engaged in marine habitat studies in Australia, Europe and America.

# The use of passive acoustics in studying marine fauna

**Rob McCauley Centre for Marine Science and Technology, Curtin University**

A surprising number of marine animals utilise sound in their behavioural repertoire. They may use sound in a variety of contexts, for example in aggressive encounters, to maintain contact, for reproductive purposes such as fish advertising spawning events or whale singing, or for sharing information on patchily distributed prey. Sounds from individual animals may travel at most in the hundreds of m to km scale for fish or small toothed whales, or into the tens or perhaps hundreds of km for great whales. Many fish and some whale species regularly call en masse, where for example many thousands of fish may call together in a chorus creating a deafening roar which in some instance may be heard by the human ear above water. These fish choruses may transmit into tens of km in appropriate environmental conditions. This propensity of animals to produce sounds, the fact that most sounds can be attributed to a species and that calling behaviour is often stereotypical and tied to some behavioural context, means that by counting calls one can obtain relative species abundance, indications of animal habits and temporal patterns in behavioural or reproduction. If sufficient information is available on the calling behaviour of a species these relative abundance estimates can be turned into absolute abundances.

With support from Defence the Centre for Marine Science and Technology (CMST) has developed a flexible sea noise logger capable of deployments from 10 to 600 m depths and which typically use a 60 GByte hard disk to give a 10 month deployment. With support from the petroleum industry and Defence these loggers have been deployed from Bass Strait westward to the shelf break north of Darwin, over the period 2000 to current. They have been used to describe various man made sound transmission phenomena, but also contain a rich cacophony of biological signals. Some of these biological signals we can identify, while many common noise types which turn up repeatedly, still cannot be identified. The development of using biological sea noise signals is in its infancy with the data collection technology relatively mature but much work to do in streamlining data processing.

Examples of intense study sites include the Perth Canyon, where sea noise loggers have been set since 2000, the Bonney coast in Victoria / South Australia, the Swan River where three seasons of mulloway calling have been recorded, the Exmouth region with loggers set on and off since 2000 and more recently in the Kimberley. The CMST and Department of Fisheries WA have embarked on a series of collaborations to use fish sounds to census mulloway and potentially bight redfish. Indications from the Perth Canyon suggest that one regular evening fish chorus reflects secondary productivity and thus can act as a simple long term indicator of the Canyon productivity. The recent IMOS scheme has supported deployment of sea noise loggers form late 2007 to 2011, in the Perth Canyon, Bonney and NSW Coasts.

# Dugong Research NW Cape – NT Border

**Mr Dave Holley**
**Murdoch University**

Currently, little is known of the abundance, distribution or habitat use and requirements of dugong outside of Shark Bay. It is strongly suspected that large-scale movement of dugong in response to severe climatic events may connect Shark Bay and Pilbara populations, though movement patterns north and east of Exmouth Gulf remain unclear. The current rapid growth of the resource sector has added to a baseline of development pressure in the State's NW with the potential to exert enormous pressure on marine fauna and their habitats. Appropriate management of dugong throughout the NW requires a fundamental understanding of the population, its movement patterns, habitat use and the key threats to those habitats. The Aim of this project is to facilitate the gathering of those strategic data.

The project will develop collaborative arrangements with Traditional Owners of country in which dugongs occur. The collaboration will follow the model developed with the Yadgalah Aboriginal Corporation in a community-driven dugong research project during 1999-2002 in Shark Bay. The development of these arrangements with communities in the Kimberley region will also be undertaken in accord with the goals and objectives for dugong and turtle management programs as set out by the North Australian Indigenous Land and Sea Management Alliance (NAILSMA) and the Kimberley Land Council (KLC).

Acquiring specific spatial and temporal data on dugong movement patterns and assessment of habitat will involve the attachment of Satellite and GPS location generating tags as well as separate Time Depth Recorders (TDR's). The fine scale delivery of these data will allow identification of core use areas and subsequent characterization of those habitats. The first deployment will be in Exmouth Gulf in the Pilbara, a region with documented changes in abundance and in which dugong density is relatively high, but where little is known about localised movements and habitat preferences. Further telemetry deployments on dugongs in the coming years will focus on the Kimberley to determine the extent of both large and fine scale movements and the role of seasonal climatic influences on distribution and habitat availability.

# Western Australia's Marine Sponges

**Oliver Gomez, Jane Fromont and Mark Salotti,**
**Department of Aquatic Zoology,**
**Western Australian Museum**

Porifera (sponges) play a significant role in the ecology of the sea. It is estimated that approximately 15,000 species occur worldwide and approximately 5000 of these occur in Australia. Less than one third of the latter are scientifically described species. In temperate Australia the sponge fauna is particularly poorly known and Western Australia's marine environment appears to be full of undescribed species.

The importance of sponges in WA's marine environment has being rapidly recognized with a consequent increase in demand for sponge identifications from the WA Museum. With the CSIRO 'Voyage of Discovery' in 2005 between Albany and Barrow Island at depths between 100-1200 metres, a trigger point was reached in the necessity for more study on WA's sponges. At some depths, in particular 100 and 200 metres, sponges dominated the biota, forming the main benthic cover and the habitat for other organisms. More than 500 species of sponges were collected on this expedition. Consequently CSIRO produced seed funding for a two year appointment of a dedicated sponge technical officer at the WA Museum.

The aim of this position is to document the deepwater sponges from the 'Voyage of Discovery'. We have elected to achieve this by producing 'species sheets' (clear, simple and image based descriptions of sponge species) on a web based platform. These species sheets are the templates for the eventual documentation of the WA sponge fauna. We believe these species sheets will achieve the following:

a. assist researchers by supplying a tool where they can attempt their own sponge identifications
b. provide basic taxonomic information for us to describe new species and undertake the necessary taxonomic revisions to document the WA sponge fauna.
c. indicate where additional taxonomic characters are needed, such as molecular studies, to inform species groupings that are difficult to separate using classical characters.

We have started with the deepwater species when the possibly more pressing need in WA is for descriptions of shallow water species. The provision of funding dictated this choice. However, a reasonable proportion of the species found at 100 metres are likely to be found at shallower depths and consequently assist shallow water research.

The only downfall of this work is that it has a time constraint. With the enormous number of sponge species presently known from WA we hope we can attract further funding to complete this task beyond the initial two years.

# Importance of photosynthetic sponges in WA

**K. M. Usher[1], M-L. Lemloh[2], S. Toze[3], and J. Fromont[4].**

**1. Department of Microbiology, University of Western Australia, Western Australia.**
**2. University of Stuggart, Germany.**
**3. Land and Water, Commonwealth Scientific and Industrial Research Organisation, Western Australia.**
**4. Department of Aquatic Zoology, Museum of Western Australia, Western Australia**

How important are photosynthetic sponges in temperate WA? A common assumption that symbioses with photosynthetic organisms are significantly more prevalent in oligotrophic waters of tropical and sub-tropical regions than in temperate waters has rarely been established quantitatively. Photosynthetic symbioses occur in a large taxonomic range of sponges, contributing 80 % of host carbon requirements in some instances, in addition to UV protection and biochemical defence. This significantly enhances host survival, growth and productivity. Several studies indicate that 40 to 50 % of sponges in tropical regions have photosynthetic symbionts, the most common of which are cyanobacteria. However, it is not known what percentage of marine sponges depend on photosynthetic symbionts in temperate regions. We used a Diving PAM, molecular analyses and classical taxonomy on sponge/cyanobacterial symbioses in temperate Western Australian waters. Our findings suggest that these symbioses are abundant and important, possibly to an equivalent degree as in tropical regions. We don't yet understand the implications for the impact of climate change on temperate reef ecosystems. We hope to expand this research in the future to explore the effects of depth, temperature and sediment and pollution load on the abundance and diversity of photosynthetic sponges.

# An Amazing Archipelago

**Diana S. Jones**
**Executive Director – Collection & Content Development**
**Western Australian Museum**

The WA Museum/Woodside partnership explored the marine environments of the Dampier Archipelago in the north west of Western Australia. A substantial research element (one dredging expedition, three diving expeditions and an international workshop) was associated with the project and the information acquired has been made widely available to diverse audiences. The resulting *Woodside Collection* (>4,500 identified species) is the first major collection in the North Eastern Indian Ocean and presents opportunities for years of further study and research. There are also numerous new species currently being described. The present total number of species signals that the Dampier Archipelago is a rich area, in terms of marine biodiversity, in Western Australia, comparable to the rich biodiversity found in northern Queensland.

# Overview of Biological Oceanography

**Anya M. Waite**
**Group Leader, Biological Oceanography**
**School of Environmental Systems Engineering**
**University of Western Australia**

For the last 10 years, our group has aimed to understand the mechanisms linking plankton dynamics, climate and fisheries, especially focusing on a particle dynamics approach. I outline some of the major field studies and their scientific outcomes, including Southern Ocean iron enrichment, carbon fluxes in fjords, and the first major work on the Subrtopical Convergence. These field programs have generated complex data sets which we then use as a basis for process modelling of particle dynamics using a wide range of approaches. Models help us understand particle aggregation, sedimentation and resultant biogeochemistry.

# The Significance of Historical Collections: Ningaloo

**Jane Fromont, Patricia McKenzie and Aquatic Zoology staff,**
**Department of Aquatic Zoology,**
**Western Australian Museum**

Collections of marine organisms have been undertaken throughout Western Australia by Western Australian Museum staff since the 1950s. Databasing of Museum collections began in the late 1980s, but until the 1990s focused on the vertebrates. Although most new collections are databased as they arrive at the Museum, there are not enough resources (staff time and funds), to database the historical collections.

With the advent of a strong research focus on the Ningaloo Marine Park in recent times, we could perceive the value of databasing the marine invertebrate collections from this region. These collections are derived from fieldwork undertaken by WA Museum staff between the 1960s to the late 1980s at Ningaloo, North West Cape and Exmouth Gulf. These collections are particularly valuable because they predate the *Drupella* outbreaks and coral spawning deaths at Bill's Bay, and the effects of the more recent cyclones.

Because of the Museum's success in securing National Ocean's Office funding, we are now able to employ a part time staff member for one year to undertake this project. The aim of the project is to database the common marine invertebrates from Ningaloo. This includes the scleractinian corals, the echinoderms, various crustacean groups including the shrimps, lobsters, and crabs, and certain molluscan families including the giant clams, oysters and volute gastropods.

Approximately 220 species of scleractinian corals, collected from Ningaloo, have now been databased. The echinoderm databasing is presently underway with seventy-two species of brittle-stars, 35 species of crinoids, 43 species of echinoids and 30 species of holothurians databased to date. The seastars will be databased shortly.

We believe that the databasing of these collections will provide valuable baseline data for future fieldwork in the region. This work will produce a consolidated database of invertebrate species recorded from the area, with associated location, depth, date of collection and habitat data. The work will identify geographical gaps (areas where few specimens have been collected), and taxonomic gaps (where particular taxa have not been collected) in the region.

We hope that we will be able to attract further funding so that databasing of the historic marine collections held in the WA Museum can continue.

# Habitats and biodiversity of Ningaloo Reef lagoon

**Halina T. Kobryn (Murdoch University, School of Environmental Science)**

This project is part of the CSIRO Flagship Wealth from Oceans, Ningaloo Cluster: “Reef use, biodiversity and socio economics for integrated management strategy evaluation of Ningaloo”

This project is run from Murdoch University in collaboration with Curtin and Queensland Universities. Airborne hyperspectral data have been acquired by HyVista through the efforts of AIMS and sponsored by BHP Billiton. The project will focus on mapping the habitat components and bathymetry and describing biodiversity of the area. Curtin University is undertaking the preliminary processing of the airborne data and creating the bathymetry model of shallow waters. Murdoch University in collaboration with AIMS, BHP, HyVista and Curtin University are working on the habitats and biodiversity.

Over the three years, this project will use the hyperspectral data to develop a high-resolution characterisation of the reef and shallow water habitats of the Ningaloo Marine Park that will provide the basis for future multiple use management and planning of the area. This project will also develop a high resolution characterisation of terrestrial land use and distribution in relationship to marine habitats.

Biodiversity values of selected areas of the reef will be described qualitatively and quantitatively in relationship to the bio-physical environment, patterns of reef use and access from land, linking these with physical and/or biological surrogates to enable specific biodiversity values to be applied across the entire Ningaloo Marine Park.

This project will also provide the basis for the interpretation of human resource use (Project 1), and essential layers of information for the destination modelling (Project 3) and management strategy evaluation (Projects 4 &5).

# Rottnest Island shallow water habitat mapping using hyperspectral data

**Matthew Harvey**
**School of Environmental Science**
**Murdoch University**

The oligotrophic coastal waters of Western Australia provide a unique opportunity to apply hyperspectral remote sensing techniques in temperate latitudes. This project aims to use HyMap images of Rottnest Island to create thematic classification maps of the marine benthic habitats for use as a planning tool by managers and planners. A spectral reflectance library has been created for the dominant marine benthic substrates in the shallow waters of Rottnest Island Reserve. Reflectance spectra were collected *in-situ* in water <10 m depth using a Ocean Optics USB2000 spectrometer fitted with a 30 m fibre optic cable, operated by a SCUBA diver. The dominant substrates that have been sampled include bare sand, seagrass (*Posidonia* and *Amphibolus*), *Ecklonia radiata* and *Sargassum* spp. HyMap hyperspectral images of Rottnest Island Reserve were flown in April 2004 at 3.5m resolution in 125 spectral bands (450 – 2500 nm). Preliminarily classification of these images has been carried out, using the spectral library, to create habitat maps of the island. Such habitat maps are essential tools for marine planning, conservation and management.

# Ningaloo: Characterisation Of Geomorphology And Surface Sediments

**Lindsay Collins, Emily Twiggs, and Alexandra Stevens**
**Department of Applied Geology, Curtin University**

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. Previous geoscientific work has established a chronology of reef development during MIS 1 to 5 (last 100,000 years) through coring, U-series dating and seismic profiling; mapped coastal evolution by GIS; and commenced a program of documenting lagoon substrates and communities using remote sensing supported by video transects.

Within WAMSI Node 3, this project will generate a fully georeferenced GIS data base and regional map of the distribution of present day sedimentation, both in the lagoon and on the shelf to seaward of the reef crest. The geomorphology and growth history of the reef system and adjacent shelf will be documented using a combination of acoustic mapping, seafloor sampling, and shallow coring. Physical factors including geomorphology, sediment composition, mobility of substrate, bathymetry, the hardness and roughness of the seabed and water depth will be significant in describing the distribution of benthic biota and habitat types over the region. The relationships determined at this scale will improve our understanding of habitat variability and be used to aid in the production of offshore habitat maps for the NMP. The program of lagoon substrate mapping will be expanded using new remote sensing data, and the pattern of coastal change at historical timescales will be established. The relationship between reef growth and sea-level change during the Holocene (last 10,000 years) will be established to provide a basis for assessment of the likely impact of future climate and sea-level change on reef and coastal responses.
The degree to which past sea-levels and ancestral reef morphology, linked to earlier events of reef growth, provide controls on present day substrates, communities and patterns of reef development is likely to be significant, and this will be fully evaluated.

# Temperature profiles of sea turtle nesting beaches in Western Australia

**Gerald Kuchling[1] and Keith Morris[2]**

**[1]School of Animal Biology, The University of Western Australia**
**[2]Fauna Conservation Program, Science Division, Western Australian Department of Environment and Conservation**

Four species of sea turtles - Loggerhead turtle *Caretta caretta*, Green turtle *Chelonia mydas*, Hawksbill turtle *Eretmochelys imbricata*, and Flatback turtle *Natator depressus* - have nesting populations of global significance in Western Australia. So far sea turtle research in Western Australia has focused mainly on the tagging of nesting females to estimate the size of nesting populations and to generate data on migration and on monitoring individual nests. Virtually nothing is known on the demography of sea turtle populations, including sex ratios of adults, juveniles and hatchlings.

Sea turtles have temperature dependent sex determination, with warmer egg incubation temperatures producing females and cooler temperatures males. Sex ratios of nests are influenced by climatic conditions of nesting beaches and may show substantial seasonal variations. Sea turtles are known to nest along the Western Australian mainland coast and on many islands from the Shark Bay to the Kimberley. Several species have extended nesting periods (peak nesting along the west coast generally occurs between October and March) and nest along a gradient of latitudes. This suggests that nest temperatures and hatchling sex ratios of sea turtles in Western Australia may vary spatially and temporally.

We measure sand temperatures at nest depth (standardised at 50 cm depth) at most major sea turtle nesting beaches on the Western Australian mainland from Carnarvon to the Dampier Peninsula and on the Dirk Hartog, Muiron, Barrow, Rosemary, Lowendal, Montebello, and Lacepede Islands for up to 2 1/2 years. Thermochron iButtons log temperatures in four hour intervals. Depending on beach profiles and the area used by sea turtles for nesting we deploy one logger at 50 cm depth just above the high water line where the lowest nests are found and a second 59 cm deep logger plus one at 10 cm depth near the highest nests at the dune crests. Data collection started in September 2004 and will be completed in 2007.

Southern beaches are generally cooler than beaches further north. Sand temperatures increase during the start of the peak nesting season and highest sand temperatures (> 30°C) are generally measured in February and March. Among year variability includes the passage of cyclones. No major cyclone passed through the study area in 2004/05, but several in 2005/06 and 2006/07. During and after cyclones sand temperatures drop down significantly.

This study will provide an overview of temperature variations at sea turtle nesting beaches and will only allow rough estimates of sex ratio variations according to published male and female producing temperatures for the different species. The data will indicate potential geographic and seasonal differences in the production of male and female hatchlings at nesting beaches and provide a baseline for more targeted research into hatchling sex ratios at particular beaches.

# Interactive effects of ocean climate, disturbance regimes and eutrophication on kelp beds

***Research team & collaborators:*** **Thomas Wernberg[1,2,*], Gary Kendrick[2], Mads Thomsen[1], Fernando Tuya[1], Peter Staehr[3]**
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***Funding base****:* ARC Discovery project, 2005-2007 (will extend into 2008).

***Aim, approach and research questions****:* Global climate change is causing an increase in temperature and storm-activity at mid-latitudes (IPCC, 2007). At the same time, human activity is increasing in many coastal areas, such as the SW coast of WA. This project ***aims*** at testing the interactive effects of ocean temperature, disturbance regime and nutrient addition on the resilience of temperate reef communities. Our ***approach*** is 'space-for-time' substitution, taking advantage of the gradual change in ocean temperature along the SW coast of WA. To test the effects of ocean climate, we conduct identical field surveys and experiments at four locations (Cape Leeuwin, Perth, Jurien Bay and Kalbarri). We work mainly on 10-12m deep, wave-exposed (offshore) reefs. ***We have four broad research questions***: (1) do kelp–associated reef communities vary systematically along the ocean temperature gradient; (2) to what extent has *Ecklonia radiata*, and other dominant organisms, adapted physiologically to the gradient in ocean temperature? (3) is there a negative relationship between ocean temperature and resilience of kelp beds to physical disturbances?, and (4) does the timing of disturbances and nutrient enrichment exacerbate the effects of ocean temperature on kelp bed resilience.

***Results to date****:* We have found that dominant species (e.g., *E. radiata*) are consistent between Cape Leeuwin (34$^{o}$S) and Kalbarri (27$^{o}$S). There is substantial variation that cannot be attributed to ocean climate. Fish are more influenced by reef-specific properties than latitude and mobile benthic invertebrates are patchy. Patterns of *Turbo* distribution suggest that regional differences in predation pressure, food quality, and temperature determine the abundance and size distribution of this species. Assemblages of small gastropods were found to differ between algal habitat types. Differences were consistent across latitudes and were consistently reduced by wave exposure.

Our physiological experiments show significant systematic physiological differences among locations. Kelp appears to have a marked capacity to adjust its metabolic machinery to ambient conditions. We found no effects on optimum temperatures for photosynthesis, respiration or rates at optimum, but there were negative effects on ocean temperature on pigment concentrations and temperature sensitivity of metabolic rates (Q10-values)

We are currently testing interactive effects of ocean climate, spatial extent and intensity of disturbance, on recovery of kelp communities following physical disturbances. The preliminary patterns of kelp recovery are convincing: disturbances at the two southern, cooler, locations show clear signs of recovery regardless of extent and intensity of disturbance. In contrast, there are limited signs of recovery at the two northern, warmer, locations. These differences in resilience to disturbances are associated with differences in recruitment, with an interaction between ocean climate and intensity of disturbance: in the cool ocean climates there is a positive effect of complete canopy removal on net recruitment whereas the effect, relative to canopy thinning, is negative in the warmer ocean climates. In short, there is a shift from competitive to facilitative canopy-recruit interactions with increasing latitude and ocean temperature. We have set up the winter component of an experiment to test the interaction between ocean climate, nutrient enrichment and time of disturbance on kelp recovery. Contrary to expectation, the preliminary results indicate that nutrient enrichment may promote kelp recruitment, and with a higher effect size at the northern latitudes (warmer ocean climates). This may reflect the generally low nutrient levels of the WA coastal waters and higher metabolic requirements for nutrients at high temperatures. So far, we only have data from disturbances initiated in winter, where the hypothesized negative effect of growth of turf was expected to be minimal. Summer treatments will be initiated this summer.

In summary, the main temperate reef communities are fairly consistent along the latitudinal gradient from Cape Leeuwin to Kalbarri, presumably because the dominant assemblage formers can adapt and acclimate to high ocean temperatures. At low latitudes (warmer temperatures) the cost appears to be a reduced metabolic flexibility and increased sensitivity of recruits to intense disturbances. The implication is that, in warmer ocean climates, temperate reef communities have a lower capacity to handle increasing levels of physical disturbance and other stressors that may require additional adaptation. This suggests that management of more localised human pressures is critical in order to mitigate the negative effects of climate changes.

# Trophic ecology of coral reefs: the role of oceanographic-to-organism scale processes in trophodynamics and benthic-pelagic coupling

**ALEX S.J. WYATT[1*], ANYA WAITE[1#], STUART HUMPRIES[2], RUSS BABCOCK[3]**
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*** PhD Candidate, [#]Primary Supervisor (Presenting)**

This study represents the first attempt to link benthic ecology and biological oceanography to elucidate the extent and mechanisms by which coral reefs are nutritionally linked to the surrounding pelagic environment and susceptible to its alteration. Focusing on Ningaloo Reef, a coral reef of key ecological importance off Western Australia currently being considered for World Heritage listing, the study aims to quantify the importance and mechanisms of delivery of pelagic sources of nutrition at scales ranging from regional to the microscale. The importance of the surrounding ocean to fringing reefs such as Ningaloo is largely unknown, but such understanding is essential for predicting and managing the impacts on coral reefs of anthropogenic and climatically-induced change to ocean systems, and therefore the effective conservation of reefs. In addition to addressing primary research questions, the project will provide baseline data essential for validating a hydrodynamic/biogeochemical model being developed to allow prediction of the impact of various climate and pollution scenarios on coral reef ecosystems resulting from interaction with complex oceanographic process.

In 1930 Sir Maurice Yonge wrote “Few subjects of such obvious zoological importance are so obscure as the nutrition of corals and the significance of their zooxanthellae. Until these problems are fully elucidated, knowledge of the fundamental conditions controlling the formation of coral reefs must remain imperfect” [1]. Although understanding of coral nutrition and the role of the zooxanthellae have increase greatly since this time, there are still fundamental gaps in knowledge that prevent a full understanding of coral reef function, and by association the response of coral reefs to change, anthropogenically-induced and otherwise. This study aims to redress the lack of knowledge regarding several aspects of coral nutrition, focusing on the role of pelagic sources of nutrition in the benthic structure and function of coral reefs.

1. Yonge, C.M. (1930) *Scientific Reports of the British Museum*. British Museum, London, pp 13-57

# Setting up the microbial food web- Particles and Picoplankton Eddy Cruise May 2006

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Eddies are known to be efficient mechanisms for the transportation of material throughout the ocean. Relatively high resolution data on their vertical structure have only recently become available. In May 2006 an eddy, that was forming in the eastern boundary current of the Indian Ocean, was investigated. Stations spaced at 10 km intervals along a North/South transect through the eddy centre, reveled well defined, complementary physical, chemical and biological structures. The eddy was attached to and fueled by the Leeuwin Current, whose signature of low salinity, warm water may be seen in the northern extent of the eddy. The core of the eddy is defined by modified Leeuwin Current water and has higher than average silicate and nitrate, but is has a reduced concentration of small particles (<500 µm) and the cyanobacteria - *Synechococcus* spp. The body of the eddy, while having a similar salinity to the core, has a reduction in silicate. Nitrate is reduced to a depth of 75 m, but has its highest concentration at a depth of ~150 m. The greatest abundance of *Synechococcus* spp. is in the top ~50 m, above the nitrate maximum suggesting that nitrate drawdown has occurred. The main body of the eddy is bounded by a salinity maximum layer which is depressed to a depth of 270 m and the centre of the eddy. These data suggest that eddies form from the Leeuwin Current result in a substantial perturbation of the environment in this region.