western australian
marine science institution

# Monitoring for action

**Symposium abstracts**

*24 November 2009*

*Understanding Western Australia's changing marine and coastal environments*

Murdoch University
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*WAMSI and Goojarr Goonyool Aboriginal Corporation Whale Monitoring Team - Pender Bay, September 2009.*

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The Western Australian Marine Science Institution (WAMSI) would like to thank the members of the *Monitoring for Action* Organising Committee for putting the symposium together. They were Dr Steve Blake (WAMSI, Chair), Ms Sue McKenna (WAMSI), Ms Lynne Stephensen (WAMSI), Ms Linda McGowan (WAMSI), Dr Kim Friedman (Department of Environment and Conservation), Dr Chris Simpson (Department of Environment and Conservation), Dr Jamie Oliver (Australian Institute of Marine Science), Dr Jane Fromont (Western Australian Museum) and Dr Paul Lavery (Edith Cowan University).

*Cover photo courtesy of DEC.*

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## Session 3: Reaching for answers – practical experiences from monitoring programs

*Chair: Professor Neil Loneragan, Murdoch University*



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*Chair: Dr Andrew Heyward, AIMS*



## Session 5: Closing and wrap-up of day

## Introduction

# Monitoring for action: understanding Western Australia's changing marine and coastal environments


Dr Steve Blake

**Dr Steve Blake**
*Chief Executive Officer*
*Western Australian Marine Science Institution*

Western Australia's marine and coastal environments are undergoing constant change. Plant and animal communities come and go on various temporal and spatial scales.

One of the key challenges to all scientists lies in discerning the natural ambient variability associated with natural change and for example, the additional contribution of man-induced or anthropogenic changes to the system. Fundamentally, this requires an understanding of what is there, how it is influenced by the physical environment and developing the necessary baselines for future comparison. For example:

*As a monitoring program, the goal is to document change - i.e. where, how much, and what kind of changes take place in the study areas at 52 different reefs. The ideal is to resolve change at scales which will allow judgements to be made as to which changes are within normal, natural variability, and which are outside it* [Ref: AIMS web site: Long-term Monitoring Program on the GBR underway since 1992].

*Many marine and coastal values are monitored and if they are under threat, action can be taken to manage potential impacts and prevent or minimise further damage* [Ref: DEC web site].

*Eradication of introduced marine species is extremely difficult. Early detection and monitoring are vital tools in eliminating and controlling the further spread of marine pests* [Ref: WA Fisheries web site].

So clearly the link between monitoring and 'management' is a highly important and focussed one and marine management agencies have an ongoing requirement for such activities to inform their decision making. The questions we will pose in the future will also, to some degree, draw off the monitoring programs of today. We monitor to inform our decision-making to allow us to take some type of management 'actions', the theme of the symposium.

*Photo courtesy of DEC.*

Some talk of habitat mapping, others of community and assemblage mapping, others of mapping the natural values of the ecosystem. Monitoring programs commonly directly inform *Pressure-State-Response* models which are used as a framework to themselves inform State of the Environment Reporting. The PSR model has three main elements:

- **Pressure:** the human activities that affect the environment, habitat or taxonomic group;
- **State:** what is known about the status or health of the environment, habitat or taxonomic group; and
- **Response:** the actions taken by society to relieve or manage these pressures.

Add to this discussions on indicators (there are 19 nationally agreed indicators under the *National NRM Monitoring and Evaluation Framework*), matters for target, resource condition indicators, community monitoring and other issues, and the whole monitoring space becomes confusing.

Monitoring is therefore not as straightforward as we may like to think. Like all aspects of science it has its 'best-practices' and its 'tricks for young players'. What scale do I monitor at? Will my data have sufficient spatial resolution? Will my data have a sufficient statistical power to discern change? Can my monitoring program link into other similar programs? I now have to reduce my sampling intensity by one third, what sites do I drop off to maintain the 10 year study? These are the types of questions we all commonly confront.

The symposium: *Monitoring for action: understanding Western Australia's changing marine and coastal environments* has therefore been organised with this in mind. The aim of the symposium is not to look into the detail of one particular monitoring technique or method *per se*, but instead to come at the whole marine and coastal monitoring challenge to understand why we monitor in the first place, how best to go about it to give the study every possible chance of succeeding, and having a long enough temporal duration to track natural and anthropogenic process change. We look at the data management issues and the issues around management uptake of monitoring outputs, both keystones in any successful monitoring program. Building flexibility into your monitoring program, the spatial nesting of monitoring initiatives and making them scalable for future expansion are also keys to success.

Five sessions have been developed to lead us through the considerations for establishing and sustaining a marine and coastal monitoring program:

**Session 1:** The background to scientific monitoring and what are the current national and international initiatives with examples of best-practice;

**Session 2:** The seascape of monitoring in WA – who is doing what locally and what are the State's ongoing requirements;

**Session 3:** Reaching for answers – practical experiences from monitoring programs;

**Session 4:** Working smarter, not harder – working together to maximise the ongoing effects of undertaking such monitoring efforts; and

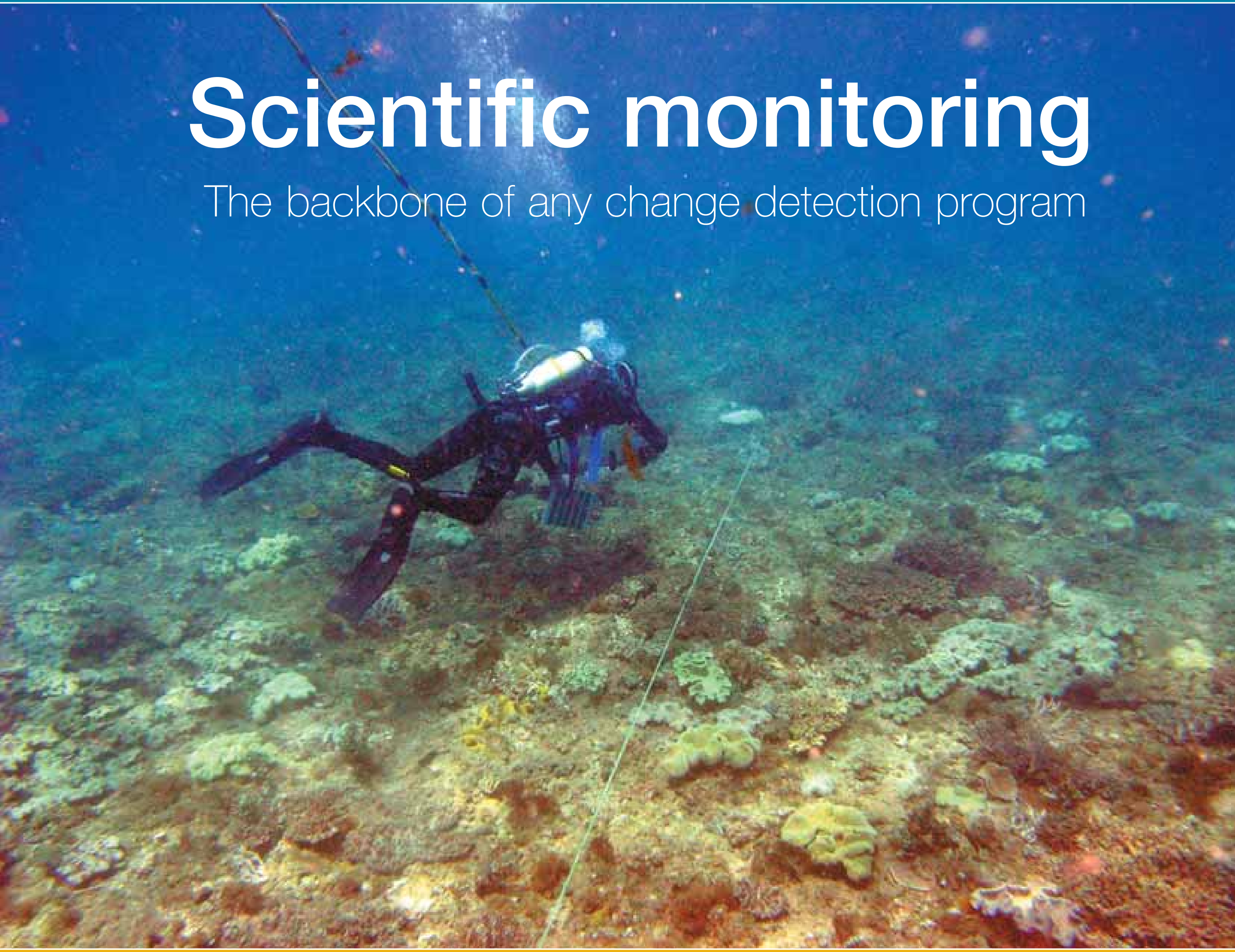
**Session 5:** Wrap up of the day and getting your monitoring outputs taken up in the management and policy arenas.

WAMSI would like to thank the WA Museum for providing the venue, the agency sponsors for supporting the symposium and the presenters who have brought to the event their vast experiences (*the good, the bad and the ugly!*) over many decades of planning, undertaking and evaluating marine and coastal monitoring initiatives. Enjoy the symposium.

Session 1

# Scientific monitoring

## The backbone of any change detection program



*A researcher records a coral transect. Photo courtesy of Dr Jim Stoddart.*

## Keynote address

# What and why are we monitoring? An international and national perspective


Dr Jamie Oliver

**Dr Jamie Oliver**
*Science Leader, Western Australia*
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Monitoring is a standard component of many government and industry funded environmental programs. It is a vital tool in determining the impacts of anthropogenic activities, the effectiveness of management interventions and the underlying natural variability of the natural system. Because of the multiple issues which monitoring programs can be targeted at, and because there is a tendency to implicitly target multiple question over several spatial scales and time frames, many monitoring programs end up being unable to provide the clear and conclusive results which are needed by managers and developers. This talk will review the key components of a successful monitoring program and will highlight the importance of careful planning and design. Some of the lessons learned from successful and less successful programs in Australia and internationally will be reviewed.

*Western Australian Museum's Dr Jane Fromont with samples destined for the WA Marine Bioresources Library.*

*Kimberley marine region.*

# Nationally, what should we be measuring?

**Dr Geoff Hosack**
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Ecological indicators reduce the complexity of real-world systems to a small set of key characteristics that are useful for management and communication purposes.

Reducing the complicated dynamics of natural ecosystems to a small number of indicators, however, represents a significant scientific challenge. Many theoretical methods used for identifying indicators, such as unstructured lists, objective-indicators matrices, cartoons and influence diagrams cannot realistically predict the behaviour of ecological indicators in complex ecosystems subject to multiple simultaneous pressures. Qualitative and quantitative models provide the most realistic solution to this problem.

This talk presents a national approach to identify indicators based on the following components: a) a set of key ecological features or values that we wish to preserve, together with an analysis of the drivers and pressures that threaten these values; b) mapping of values and pressures to identify trends and patterns of co-occurrence; c) qualitative modelling to identify potential ecological indicators among the ecological features that are exposed to threatening processes; and, d) indicator selection criteria to identify suitable indicators from a list of potential indicators.

# Case study of a long-term monitoring initiative: The Australian Institute of Marine Science (AIMS) Great Barrier Reef monitoring program

Dr Hugh Sweatman

**Dr Hugh Sweatman**
*Research Scientist*
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The AIMS Great Barrier Reef (GBR) long-term monitoring program grew out of a program to survey the GBR for crown-of-thorns starfish outbreaks in the 1980s. In 1992, the program added surveys of reef fishes and benthic organisms on fixed transects in a standard habitat on about 50 reefs spread systematically across the central and southern GBR, with the aim of providing situational awareness for much of the GBR marine park.

Preliminary reports are made available by email and on the internet within two weeks of survey cruises. Web pages on individual survey reefs are updated annually and status reports that include regional and overall summaries. This program has been a major source of information for the GBR MPA State of the Reef Report and the 2009 GBR Outlook Report, which provides the link back to policy and management.

In 2006 the program was revised so that the long-term survey sites were surveyed every other year, alternating with similar surveys of a different set of pairs of similar reefs designed to monitor the effects of the new zoning plan that was implemented in 2004 on reef fishes and benthic organisms. This program has shown a rapid increase in target species in no-take zones, but there is little evidence for indirect effects on non-target species.

There is considerable emphasis on data quality control, data management and rapid reporting.

## Compliance monitoring for industry

# Industry monitoring in the nearshore of North West Australia

Dr Jim Stoddart


**Dr Jim Stoddart**
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The north-west Australian coast is a major interface for shipping mineral resources offshore or bringing hydrocarbon resources onshore. As well as hosting the shipping and shiploading infrastructure, this area holds processing works and the population servicing these industrial needs. All this comes with a range of actual and potential impacts on the nearshore marine environment. Typically, impacts derive from the activity of large companies with large identifiable projects or facilities where impacts are subject to assessment and regulation under the WA or Commonwealth environment acts. This results in a wide range of monitoring programs, including programs directed at:

- reactive management,
- compliance testing, and
- knowledge improvement.

Monitoring programs designed to meet the needs of the first two frequently employ an impact-reference dielectic to imply causation. However, with the location of impact sites and the extent of the impact normally outside the control of the program designer, this may not be useful. Baselines are too short and interannual variation too large to allow effective use of baseline statistics to identify exceedences from the routine.

*The Angel platform on the North West Shelf. Photo courtesy of Woodside Energy.*

Some examples of monitoring programs from the Pilbara and Kimberley will be used to illustrate the problem.

*The work team checks the instrument on a telemetered water quality logger.*

## Working with private industry in marine monitoring

# Recent experiences from monitoring programs in North West Australia

**Dr Russell Hanley**
*Executive Marine Scientist*

**and Dr Martin Heller**
*Marine and Coastal Science Group*

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Dr Martin Heller

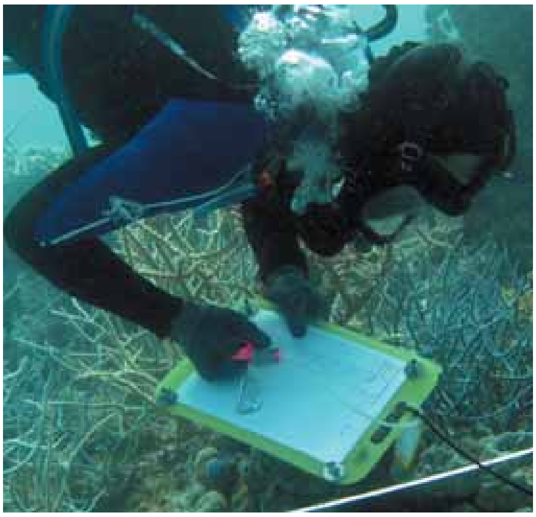

Dr Russell Hanley

The Marine and Coastal Science Group of Sinclair Knight Merz has been engaged in a variety of environmental baseline and monitoring programs in the Pilbara region since 2006, with a focus on the development of ports infrastructure requiring large scale capital dredging.

Many areas of the Pilbara region are information poor and a major impediment has been the lack of baseline data on water quality, habitat types and distributions, community stability through time, and critical thresholds for the assessment of impact upon 'sensitive' communities.

The MCSG has been guided by previous dredging programs and associated environmental approvals in the Pilbara, but has also spent considerable effort, with the support of clients, in the investigation of new approaches to many of the environmental issues that are common to most infrastructure development in the region.

Several examples are presented of improvements in mapping and delineating marine benthic habitat types, including the identification of change through time and the potential drivers of observed changes.



*Photos courtesy of SKM.*

Session 2


*Photo courtesy of DEC.*

## Ecological

# State outlook for marine monitoring, evaluation and reporting: A Department of Environment and Conservation perspective

Dr Kim J. Friedman

**Dr Kim J. Friedman**
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*Marine Science Program*
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*The Department of Environment and Conservation's Marine Science Program staff.*

Australia is a marine nation. We have one of the largest ocean territories in the world, and employ numerous tools to sustainably manage coastal systems for the benefit of present and future generations. In this regard, Commonwealth agencies are committed to strategic research to gain a fundamental understanding of how oceans work and how they interact with the atmosphere, land, biological cycles and people. For the States and Territories, industry, environmental and fisheries agencies, industry regulation and planning authorities, local councils and community groups oversee and manage resource interests, boating, extractive use, and safety and industrial development activity at scales appropriate to human activity.

The Department of Environment and Conservation (DEC) is Western Australia's primary biodiversity conservation agency. Its key responsibilities include broad roles in conserving biodiversity and protecting, managing, regulating and assessing many aspects of the use of the State's natural resources. Specific to the marine sector, DEC operates across the State in relation to managing human impacts on biodiversity and threatened marine fauna and regulating resource use (generally non-extractive uses). A focus of DEC's marine biodiversity management is in the form of a statewide network of marine protected areas (MPAs). DEC manages MPAs under a range of spatial and 'activity' controls, implementing an active adaptive management process to conserve ecological and social assets and mitigate anthropogenic pressures.

Information on the condition of assets, pressures and management response within and across MPAs is integral to the audit function of the Marine Parks and Reserves Authority (MPRA). The audit process to oversee DEC's management performance is legislated within Section 26B of the *Conservation and Land Management Act 1984* (CALM Act) and is a core element in the MPRA's annual report to Parliament.

In late 2008, DEC established the Western Australian Marine Monitoring Program (WAMMP), which is primarily a partnership between its Science Division (via Marine Science Program) and Regional Services Division. WAMMP also has access to environmental data from the temperate and tropical research groups of the Marine Science Program and information from DEC specialist branches (e.g. Marine Ecosystems Branch and Environmental Management Branch in relation to industrial environmental impact assessments and compliance monitoring).

The WAMMP will establish reference sites at representative and relatively undisturbed locations in all WA IMCRA bioregions to measure a suite of ecosystem condition indicators, particularly indicators that are reflective of human induced changes to ecosystem condition. These sites will be complemented with sites indicative of anthropogenic and climate change pressures at appropriate spatial and temporal scales. In order for WAMMP to deliver a world-class monitoring, evaluation and reporting system across the State we need to:

(i) Determine the status and trends in selected indicators of condition of recognized assets, the pressure/s on the assets and the effectiveness of management responses;

(ii) Provide better understanding of the dynamic nature of undisturbed ecosystems and provide reference points for comparisons with altered environments;

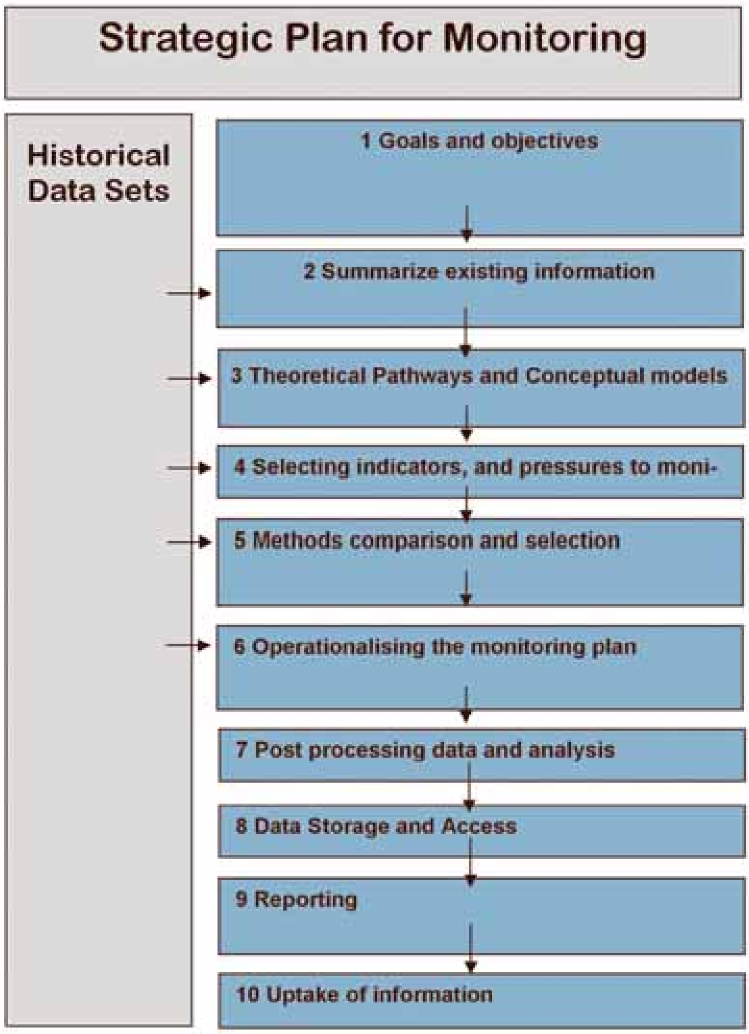
(iii) Provide warning of condition change to allow early development of effective mitigation measures; and

(iv) Provide information to meet community audit requirements and allow measurement of progress towards ecological performance and community appreciation goals.

WAMMP is currently in its establishment mode for its Statewide program. A strategic plan for the program has been finalised, as have draft knowledge reviews for priority biodiversity assets across the State. These outline WAMMPs approach to monitoring under the Condition / Pressure / Response model adopted by DEC. Implementation of fish community and key benthic community monitoring that is guided by knowledge reviews and historical datasets is currently underway, and this will be followed by monitoring of the other assets in the required suite as the program matures.

Under WAMMP the realisation of long-term fundamental datasets over an expansive spatial area and a broad range of assets will require significant effort. These objectives and the working strategies that underpin WAMMP would benefit from input by other agencies, and DEC will look to share information with other statutory and non-statutory bodies in recognition of their roles. For example the Department of Fisheries (DoF) is a key player in this regard, as they are required to fulfill their statutory obligations in commercial and recreational fisheries, pearling and aquaculture and fish habitat protection. These obligations, and DoF's Ecosystem-Based Fisheries Model (EBFM) complement well the obligations and duties of DEC, offering a wide range of targets for complementary monitoring. Similar overlaps in activity exist with Commonwealth agencies, other state authorities like Water Corporation and Department of Water, private commerce and industry (particularly the Oil & Gas industry) and local council and district groups (e.g. NRM, community monitoring). Integration of activity within these monitoring programs and the sharing of results offers access to a wide range of information over a range of spatial and temporal scales.

This presentation defines the plan of action for WAMMP, and looks at the potential for greater integration between agencies where there is areas of joint interest or responsibility. Such integration needs to occur along the full chain of monitoring activity, to ensure clear signals emerges from public and privately funded monitoring of our coastal systems. The task ahead requires not only the structured and integrated implementation of monitoring and collaborative efforts to be made in data distribution, but also follow-up to ensure results flow back into active adaptive management cycles. This will only happen with credible, comprehensive and regular data flows on asset condition and information on stressors, and this will best be realised through active cooperation of the marine community in Australia, particularly Western Australia.



## Ports and coastal infrastructure

# WA coastal monitoring programs and their interpretation for coastline change assessment

**Mr Matt Eliot**
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Coastline change has been recognised as a likely future challenge to Australian coastal management, due to the combined pressures of climate change and increased coastal utilisation. After a hiatus of a number of years, the potential for adverse coastline change has achieved wider recognition with the Australian public and in the political sphere. Steps have been taken at all levels of government to improve the information base for coastline change assessment, allowing improved decision-making. Projects have included the 'first-pass' National Coastal Vulnerability Assessment; review and revision of historic databases; development of high-quality bathymetric data sets; and locally based climate change coastal impact assessment.

Although this 'newly acquired' knowledge base provides a basis for future assessment, its collation over a short period of time limits its capacity to help detect and interpret coastal change. Consequently, historic coastal monitoring programs provide the foundation upon which change assessment must be undertaken.

Prior to the 1990s, the majority of coastal instrumentation throughout WA was installed to assist with either port operations or the design and installation of coastal facilities. Consequently, the value of such observations as a tool for coastal change assessment is largely opportunistic, with a strategic framework of observations, including several offshore waverider buoys, tide gauges, weather stations and annual coastal aerial photography. Evidence-based studies for climate change coastal impact assessment have identified some of the strengths and weaknesses of the available historic records.

The spatial and temporal coverage of recent and historic coastal monitoring programs is discussed, with respect to their potential for coastline change assessment across WA.

## River and estuarine health

# Understanding our rivers and estuaries


**Dr Vanessa Forbes**
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*Monitoring river health. Photo courtesy of the Department of Commerce.*

Waterways are one of the most significant forces shaping our ecosystem and intrinsically linked with the overall health of the environment. Understanding our rivers and estuaries with a view to management and maintenance of both form and function, whilst balancing economic and social values, is one of the most important roles of the Department of Water.

The condition and stability of our waterways is dependent on a complex and dynamic network of interactions between biotic (bacteria, algae, plants and animals) and abiotic features (sediments, rocks, climatic features, water flow, chemicals and physical form), which often varies greatly between regions (variations in rainfall, temperature, altitude, geology, depth, flow) and over time (i.e. seasonal changes).

To better understand, assess and manage our waterways the Department of Water is looking at multiple approaches, using both monitored and modelled techniques. The Department has a significant focus on water quality and quantity, although it is investing increasing time and effort investigating sediment quality, algae and more recently plants and animals, including macroinvertebrates, fish and crayfish, seagrass and fringing vegetation.

Holistic, multiple-parameter approaches for assessing waterway health are also being employed, where a range of information is collected for each system to determine overall ecological health. This approach examines not only the condition of particular aspects of the waterway (such as water quality and fish health), but attempts to determine the ecological integrity of the system taking into account catchment inputs and interactions between components of the system. This approach is being undertaken for both rivers and estuaries.

Understanding of waterways enables the Department to better assess the health status of our systems, especially in relation to common threats and risks to our waterways.

## Oceanography and climate

# Integrated Marine Observing System (IMOS) in Western Australia

Charitha Pattiaratchi

**Professor Charitha Pattiaratchi**
*Winthrop Professor of Coastal Oceanography*
*School of Environmental Systems Engineering,*
*The University of Western Australia, Nedlands, WA 6009*
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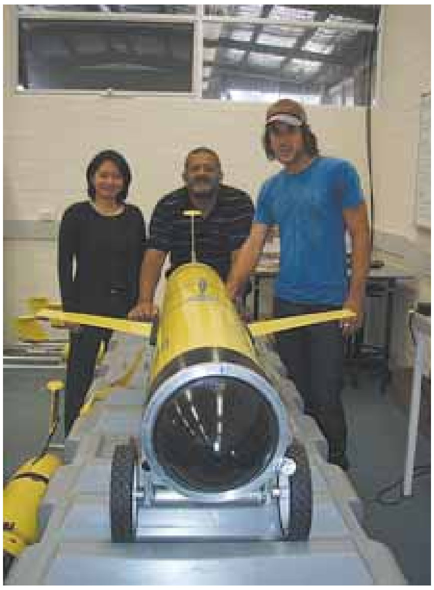
West Australian Integrated Marine Observation System (WAIMOS) is a node of the Integrated Marine Observation System (IMOS) for Australia funded through the National Collaborative Infrastructure Scheme (NCRIS).

The main area of interest for WAIMOS is the continental shelf and slope regions offshore from Fremantle extending northwards to Jurien Bay. Within this region there are important topographic features such as the Rottnest Island and Perth Canyon where circulation is dominated by the southward flowing Leeuwin Current (LC) with the northward flowing Leeuwin Undercurrent (LU) beneath the LC, and the wind-driven Capes Current (CC) located on the shelf, particularly during the summer months.

The IMOS infrastructure located in this region includes HF Radar (CODAR and WERA systems) for surface current measurements at different scales – ocean gliders (Slocum and Seagliders) for subsurface water properties, continental shelf moorings (ADCP, thermistor and water quality loggers), passive acoustic sensors for whale monitoring, and remotely sensed data products (SST and ocean colour).



*Professor Charitha Pattiaratchi and two students with an ocean glider, which beams ocean data by satellite.*

Example data collected from these instruments will be presented in relation to the understanding of different processes operating in the region. These include:

1. the interaction between the LC and CC. Here, the warmer, lower salinity southward flowing Leeuwin Current interacts with the cooler, higher saline northward flowing Capes Current creates a region of high horizontal shear and thus intense mixing; and

2. the winter cascade of dense water along the continental shelf. The region experiences a Mediterranean climate with hot summers and cold winters. During the summer months the inner continental shelf waters increase in salinity due to evaporation. In winter as the higher salinity waters cool, the density is higher than offshore waters and a gravitational circulation is set up where the inner shelf water are transported as higher salinity plumes into deeper waters.

Professor Charitha Pattiaratchi is the Winthrop Professor of coastal oceanography at the School of Environmental Systems Engineering at the University of Western Australia.

He undertook his tertiary studies at the University of Wales, Swansea, where after completing a Bachelors degree with honours in Oceanography and Applied Mathematics, he obtained a Masters and PhD in oceanography from the same institution. In 1988, he accepted a position as a lecturer at the Centre for Water Research at UWA.

He has been a Fellow of IMarEST and a chartered marine scientist since 2005.

His current roles include:

- Director of the Australian National Facility for Ocean Gliders;
- Node Leader, West Australian Integrated Marine Observation System (WAIMOS);
- Group leader, Coastal Oceanography, School of Environmental Systems Engineering;
- Graduate Research Coordinator, School of Environmental Systems Engineering;
- Chair, Numerical Modelling Group for the Indian Ocean Tsunami Warning System;and
- Chair, International Steering Committee of the Physics of Estuaries and Coastal Seas (PECS).

He also coordinated the marine science and engineering program for UWA and served as the head of the university's Department of Environmental Engineering.

He has supervised more than 30 PhD students and 100 honours students and was awarded an excellence in postgraduate supervision award by UWA in 2003.

His research interests are in coastal physical oceanography and coastal sediment transport, with emphasis on field experiments and numerical modelling, in particular, the circulation and mixing processes on the continental shelf, coastal and estuarine regions of WA and Sri Lanka. Research interests also cover sea level variability, the dynamics of island wakes and headland eddies, remote-sensing applications, effluent dispersion from outfalls, estuarine circulation and dynamics, nearshore processes and sediment transport, and the formation and maintenance of rhythmic features, such as linear sandbanks and beach cusps.

He has published more than 262 articles/reports on coastal oceanography, which include over 100 in peer-reviewed, international journals and two as book editor. He also serves on the editorial boards of many international scientific journals.

## Physiochemical

# Ocean outlet monitoring in Western Australia: targets, triggers and technical challenges

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Oceanica presently oversees the management of two major ocean outlet monitoring programs in the Perth metropolitan area [Perth Long-Term Ocean Outlet Monitoring (PLOOM); Alkimos Ocean Outlet Monitoring] and one major ocean outlet monitoring programme in the State's south-west [Bunbury Ocean Outlet Monitoring (BOOM)]. The extent and type of monitoring required for each of the program – conducted on behalf of the Water Corporation – is governed by State Government regulations, encompassing Ministerial and Licence Conditions. Monitoring has traditionally focussed on *in situ* measures of environmental quality [Conductivity-Temperature-Depth (CTD) profiles, nutrients and ecological indicators such as seagrass shoot density] with monitoring commencing following Wastewater Treatment Plant (WWTP) operation. However, more recent programmes have adopted a Multiple-Before-After-Control-Impact (MBACI) approach, by considering the state of the environment before and after commencement of treated wastewater ocean disposal. This presentation provides an overview of the PLOOM, BOOM and Alkimos monitoring programmes, and concludes with examples of the challenges faced by marine environmental managers.

### PLOOM

Commencing in 1995, the PLOOM program was established following completion of the Perth Coastal Waters Study (PCWS). The PCWS consisted of a four year (1991-1995) multi-disciplinary study investigating the effects of Perth's existing ocean outlets at Sepia Depression, Swanbourne and Ocean Reef. Although no adverse effects of the ocean outlets were detected at the time, the study advised that the ongoing disposal of treated wastewater had the potential to cause eutrophication in the future because of projected increases in nutrient loads if WWTPs were not upgraded. A major recommendation of the PCWS was that Water Corporation conduct a five-year ocean outlet performance monitoring program, including a time-series investigation of water column chemistry, sediment condition and plant and animal community structure. In the absence of pre-disturbance data (i.e. prior to the establishment of ocean outlets) these data provide a valuable data set against which present-day data are compared. Since this time, all of Perth's WWTP have undergone major upgrades to significantly reduce the loads of nutrients reaching the environment. Indeed, recent PLOOM investigations conducted between 2000 and 2009 have found no significant change in characteristics of marine sediments and no significant increase in the concentration of chlorophyll a in the vicinity of the outlets. Monitoring in the vicinity of Perth's outlets continues with the aim of ensuring the disposal of treated wastewater is sustainable, and that the Environmental Values (and Objectives), as established by the Environmental Protection Authority (2000), are maintained.

### BOOM

Commencing in 2002, the BOOM program was designed to meet Ministerial and Licence conditions, including the requirement to conduct environmental monitoring three times per annum (encompassing spring, summer and autumn). Monitoring is focussed on several water quality (physical chemical, nutrients) and two benthic environmental indicators (sediments and seagrass shoot density). Two levels of environmental protection have been established and include Environmental Quality Guidelines (EQG) and Environmental Quality Standards (EQS). Exceedance of an EQG leads to more detailed assessment against the EQS;

exceedance of an EQS leads typically to an appropriate management response. Data collected between 2002 and 2009 have indicated numerous exceedances of the EQG, but no exceedances of the EQS, indicating a measurable effect of the outlets, but no adverse environmental impacts with the potential to compromise the Environmental Values.

### Alkimos

The Alkimos WWTP is the fourth major ocean outlet to be established in the Perth metropolitan area. Although not commencing ocean discharge until mid 2010, base-line algal community monitoring commenced in February 2009 and will continue into early 2010. A clear understanding of the status of the benthic environment prior to ocean disposal forms an important part of the Environmental Management Plan and an integral component of the underlying MBACI experimental design. The MBACI programme is designed around hypothesis based tests for changes in algal community structure. The resulting long term multivariate data set will provide valuable insights into the level of natural spatial and temporal variation, and the level of statistical rigour (with consideration of effect sizes) required to detect meaningful change. The Alkimos Ocean Outlet Monitoring program is the most rigorous monitoring programme applied to any of the ocean outlets presently operating in WA. In addition to the benthic indicators developed for the MBACI program, the monitoring program also includes a number of in-water indicators and triggers. Several in-water triggers (nutrients, micro-biological and physical-chemical) have been established as the EQG, whereas benthic triggers have been established as the EQS.

### Challenges

Despite the advent of increasingly rigorous environmental monitoring programs (i.e. MBACI), environmental managers are faced with the same, age-old challenge—how to detect the beginnings of anthropogenic change in the midst of considerable natural change? This is particularly worrying when the first detectable change at an impact location may already indicate irreversible change, for example a shift toward complete dominance of one algal species over a suite of algal species. To begin the process of developing acceptable triggers, managers first require prerequisite knowledge of the extent of natural change on two scales: temporal (inter seasonal and inter annual) and spatial. This is not traditionally the case, with most examples (and those approved during the EIA process) focussing monitoring effort during and after the disturbance, and not before-hand. Armed with this knowledge, the challenge for managers is to develop triggers that are sufficiently sensitive to provide ‘warning’ but not over?sensitive such that the trigger lies within the upper range of natural variation.

*Algal community monitoring near Alkimos. Photos courtesy of Glenn Shiells.*

## Social/Community

# Community based monitoring

**Kimberly Onton**
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Kimberly Onton

Community-based monitoring refers to the involvement of volunteers in scientific studies. Community-based monitoring programs can involve a broad range of activities, from ecological observations to the measurement of environmental parameters. Whilst the collection of data by community members is not new, the number of studies, volunteers enlisted and the scope of data collected has increased with time. These programs may be led by non-government organisations or community groups for either research purposes or advocacy, or by government agencies for the purpose of public engagement or the need for assistance with data collection.

Community-based monitoring is often questioned for its scientific merit. Limitations identified generally center around the unqualified nature and high turnover of participants (observer bias) and potential inconsistencies in methods over time that may limit the utility of the data collected. Whilst these challenges are acknowledged, community-based monitoring has considerable strengths. The utilisation of volunteers allows for the collection of data on a larger geographic scale and over longer time periods than is possible with more traditional scientific research that is often limited in time and financial resources. For example, the Birds Australia Shorebirds 2020 program has identified shorebird population trends from data collected by 1100 people over 30 years from 2000 sites. Community-based monitoring can complement scientific institutional monitoring and may serve as an early warning system to trigger more detailed research. The community engagement aspect itself is valuable in inspiring community members to connect with their environment and advocate for its protection whilst becoming more aware of the complexities of natural resource management.

The Department of Environment and Conservation (DEC) recognises the value of community-based monitoring and aims to engage the community in the collection of scientific data, particularly in the State's marine protected areas as part of the Western Australian Marine Monitoring Program (WAMMP). The WAMMP will use the Marine Community Monitoring Program, a 'toolbox' of simple but effective marine monitoring methods to assist local interest, stakeholder, industry and school groups to monitor ecological and social parameters relevant to marine conservation and environmental management.

This presentation will explore the strengths, weaknesses and lessons learnt from example community-based monitoring programs and their applicability to DEC in addressing marine and coastal management in WA.

Session 3

# Reaching for answers

## practical experiences from monitoring programs

*Monitoring in the Abrolhos. Photo courtesy of the Centre for marine futures.*

## Keynote address: Why you need monitoring to evaluate the natural environment. The 'must haves' in designing any monitoring project

# A statistical framework for integrated monitoring and research in WA

Dr Jeffrey Dambacher

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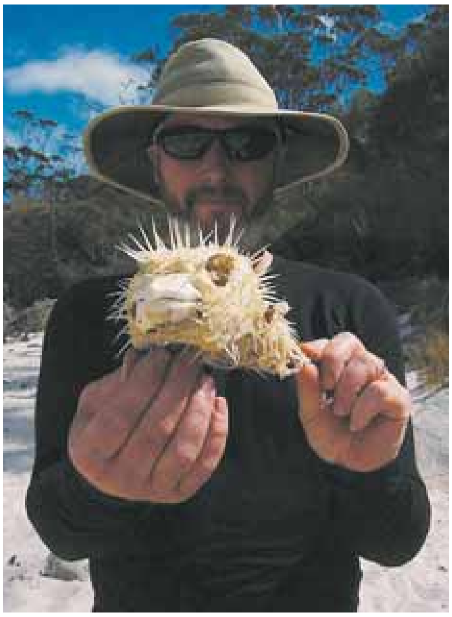
A major goal of an environmental monitoring program is to provide information that will be relevant to the needs of decision makers in the future, but long-term monitoring program are especially challenged. Often our understanding of the natural system changes, the system itself changes, or, perhaps more frequently, institutional policies change. Moreover, the questions asked range from local to regional scales, and are being asked by an array of research and regulatory organisations with objectives that are not necessarily compatible. If not adequately addressed in an integrated manner, these challenges can lead to an inefficient, ineffective, or aborted monitoring program.

Many of these challenges can be addressed through a statistical framework called the generalised random tessellation stratified (GRTS) sampling design. Developed in North America, it is gaining popularity as a rigorous and flexible approach to long-term monitoring programs. Here we provide a brief introduction of the GRTS sampling design, with applications for the monitoring of stream habitat and fish populations, and marine parks.



*Dr Dambacher on a field trip.*

## Fisheries

# Development of appropriate management units, objectives and then indicators for use in the management of fisheries and other natural resources

Dr Rick Fletcher

**Dr Rick Fletcher**
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There has been considerable level of activity and interest over the past decade to develop indicators, resource condition monitoring (RCM) targets and other similar terms, supposedly for use in natural resource management. Such activities are, however, largely pointless unless the indicator or RCM that is generated is directly associated with measuring something that clearly relates to a management objective and there is some possibility that a management action may arise if the indicator suggests poor performance.

Given the complexity of the marine systems, it can often be difficult to choose what to measure that will describe what is happening within the system. However, the more critical problem has been in determining pragmatically, what are the units of management and developing clear enough objectives that would mean the monitoring of some indicator will actually be a valuable use of resources.

This talk outlines how we are undertaking the process of simplifying the complexity of the marine ecosystem and fisheries resources down to a level such that indicators can be developed that can be monitored in a cost effective way and for which realistic management outcomes can be defined.

The talk will provide an outline of the minimum requirements for the development of the indicator, objective and performance measure package. It will also provide examples of how cost effective monitoring and management systems can be developed even for complex circumstances. It will also outline when such programs are not likely to be a valuable use of resources.

*Above: The Department of Fisheries coordinates the monitoring of WA waters for sustainable fisheries.*
*Below: Measuring a rock lobster.*
*Photos courtesy of the department.*

## Natural Resource Management

# What we learned from developing a state-wide approach to Resource Condition Monitoring in Natural Resource Management in NAP and NHT2

**Ceidwen Pengelly**
*Manager, Monitoring and Evaluation*
*Natural Resource Management Science*
*Department of Agriculture and Food WA*

Monitoring and evaluation (M&E) is an integral part of the Natural Resource Management (NRM) program cycle. It is the key to understanding whether our NRM activities, products and services are effective at protecting and managing our natural resources for the future.

The aim of investment in NRM is to improve or maintain the resource condition. Resource Condition Monitoring provides us with information about the state and trends in our natural resources. It is an important part of the NRM investment cycle.

In WA the M&E for two programs – the National Action Plan for Salinity and Water Quality (NAP) and the Natural Heritage Trust 2 (NHT2) – was coordinated through the *State NAP and NHT2 M&E Implementation Plan*. The plan has been in place since 2003.

In 2008/09 an internal review of this plan was undertaken by the State M&E team to measure progress and recommend improvements for future M&E plans.

The review found that the plan had enabled the coordination and funding of monitoring and evaluation activities, which is a significant step forward in WA.

The plan also enabled the funding of eight Resource Condition Monitoring projects worth $10 million to improve the state monitoring network and to develop monitoring protocols and install infrastructure.

The review found that the eight RCM projects have made progress, state agency technical experts have been engaged and they have made a significant contribution to monitoring in WA.

The projects have developed Standard Operating Procedures, developed and tested monitoring protocols, completed scoping studies, adjusted databases to receive information and installed infrastructure. They have made a significant contribution to the scientific knowledge of monitoring as relevant to WA. However, these projects have experienced delays to contracting and funding and thus their progress.

RCM takes a long time to plan and implement. The time required to understand what is happening in the environment can be between five and 20 years. In each field technical scientists are required to measure, analyse and report data in a way that is easily understood by decision makers and the community. This means that it is important to provide ongoing funding to maintain the capacity to continue our long-term monitoring programs.

Lastly, it was also recommended that a resource condition monitoring plan be developed to coordinate effort across state agencies and enable long-term funding.

In summary, progress has been made in RCM in WA and the state-wide monitoring network has been improved, however the uncertainty in future funding could adversely affect the progress made to date.

## Marine monitoring: Indicators

# The when and the where of marine monitoring

Jessica Meeuwig


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Two key challenges in marine monitoring are a lack of historical data and a reluctance to invest in such monitoring. The general lack of long term data sets means we are swimming blind and our baselines are shifting. The reluctance to invest in marine monitoring means that, moving forward, we are constrained both in terms of the frequency with which we monitor in time (the 'when') and the spatial coverage of our monitoring programs (the 'where').

A number of strategies exist to address these challenges. 'When' can in part be answered by annual and seasonal repeated sampling at focal locations that identifies scales of natural variability against which human induced change can be assessed. This requires investment. 'When' also requires us to creatively use available historical data sets, typically based on human use such as recreational catch records, commercial catch and effort data, mariners' logs and even art. We need to explore how these sources of information can be converted into currencies relevant to today's management. 'Where' means choosing sites that theory tells us are likely to be the marine equivalent of canaries in the coal mine. 'Where' also means collecting spatially extensive data, allowing 'space for time' modelling that provides insights into how baselines may have shifted or may shift in the future.

We need to invest in highly protected (IUCN Level 1) marine parks that help us tease apart impacts of climate change, fishing and other anthropogenic pressures and we need to invest in effective baseline surveys prior to offshore development such that we can understand the implications of change.

*Monitoring in the Abrolhos. Photos courtesy of the Centre for marine futures.*

## Swan and Canning rivers

# The value of information capital in managing the Swan and Canning rivers

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The Swan River Trust, through the Department of Water, undertakes routine estuarine and tributary water quality sampling on the Swan and Canning rivers for health assessment, phytoplankton hazard warnings, status and trends, and process understanding.

The data set is one of the most extensive available and provides essential information for the evaluation of the impacts of change on the system. The value of this data set will be explored in context of recent dolphin deaths, a water quality improvement program and climate change.

*Dolphins at Monkey Mia. Photo courtesy of Tourism WA.*

## Rottnest Island

# Off the shores of Rottnest Island – maintaining a healthy marine environment

**Roland Mau**
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*Rottnest Island Authority*

*Authors: Roland Mau, Shane Kearney (Environmental Services Coordinator, Rottnest Island Authority) Rian Caccianiga (Conservation Officer, Rottnest Island Authority), Russell Stevens (Conservation Officer, Rottnest Island Authority)*

*Rottnest island.*

Rottnest Island is one of the most popular recreation and holiday destinations in WA with up to 600,000 people visiting the Island every year. Rottnest Island is located 18 kilometres west of Fremantle at latitude 32°00 S. The island and its waters are an A-Class Reserve for the purpose of public recreation and protection of flora, fauna and heritage values. The reserve encompasses 1900 hectares of land, 38 kilometres of coastline and 3830 hectares of marine environment.

The Rottnest Island Authority (RIA) was established in 1987 as the statutory body to control and manage the Island under the *Rottnest Island Authority Act 1987* (the Act). The Act dictates that the RIA must sustainably manage the natural and cultural assets of the island. To that end, the RIA has adopted a strategic 'triple-bottom line' approach – moving towards becoming environmentally, socially and financially sustainable. The Act requires the RIA to have a five-year management plan in place, providing a legally binding statement of policies and guidelines and a summary of operations proposed for the five year period.

The 2009-2014 Rottnest Island Management Plan's (RIMP) desired outcome is that Rottnest Island visitors enjoy recreational and holiday experiences in healthy natural and cultural environments. The level of success in achieving this outcome will be measured by a suite of relevant performance indicators. Although some reporting on key performance indicators pertaining to the health of the natural environment has been undertaken over recent years, the measures for the marine habitat were largely output based and are currently under review to ensure their adequacy in meeting the RIA's Outcome Based Management Framework. The following section outlines the key values of the reserve, management strategies currently in place and an overview of existing monitoring programs.

### Ecological values

Rottnest Island's marine environment is ecologically 'special' in many ways. Its geographic isolation from the mainland and location near the Leeuwin Current have resulted in its waters being characterised by a unique blend of tropical and temperate species, with a prominent component of WA endemic species. The island also has the southernmost occurring assemblages of tropical corals in the State and possibly in Australia, and has a diverse mix of habitats and communities, ranging from coral reef to seagrass habitats.

### Social values

Rottnest Island's proximity to the Perth metropolitan area has made it a highly valued place for recreational activities. Many of the visitors coming to the island undertake marine-based recreational activities. These activities include swimming, diving, fishing, surfing, kayaking and boating amongst others. The main social features of the marine reserve include marine amenity, visual appreciation for land-based as well as vessel-based visitors, commercial/private use, and experiences of the marine environment.

Rottnest island.

### Pressures

The primary pressures on the marine ecosystem of Rottnest Island relate to its high use by visitors. These impacts include: vessel-based sewage discharge, direct extraction of marine fauna (i.e. through fishing and collecting), physical damage from vessel anchoring, divers and snorkellers, littering and disturbance.

### Current marine monitoring programs

Marine monitoring programs by the RIA were targeted to measure key indicators of the marine ecosystem health, being: water quality, seagrass, reef fish, and crayfish (*Panulirus cygnus*), and the effectiveness of management responses.

Various monitoring programs for water quality were developed in consultation with the Department of Health, Department of Water and University of Western Australia. The primary objective of these programs were to determine water quality as it relates to human health i.e. bacterial levels. The presence of the toxic blue-green algae Lyngbia majuscule. is hypothesised to be related to nutrient enrichment and monitoring sites were thus selected at high use bays to ascertain nutrient sources and quantities.

Discussions are underway with the Department of Environment and Conservation to develop a complimentary seagrass monitoring program. This will entail monitoring condition indicis such as nutrient assimilation and fluxes, leaf bundle density and shoot density, extent, diversity, depth distribution, and composition as surrogates of seagrass health. There is no baseline information currently available.

This year has seen the implementation of the Reef Fish Baseline Survey (a collaborative effort with UWA) which compliments and enhances existing datasets to create a benchmark for scientific reference and future comparisons. The survey aims to detect spatial and temporal patterns within fish assemblage structure with regards to diversity, length frequency, abundance and possibly biomass. The outcome will be to gain a better understanding reef ecosystems for improved future management purposes (such as a measuring tool for the progress of management strategies such as Sanctuary zones and compliance) and to provide recommendations for the development of a long term reef fish monitoring plan.

Furthermore, the RIA in collaboration with the University of Tasmania has initiated 'Reef Life Surveys' at Rottnest Island. The 'Reef Life Survey' program uses competent volunteers to sample fish abundances and lengths (to species), cryptic fish abundance and invertebrate. RIA is seeking to utilise this volunteer network to contribute to a quarterly monitoring plan.

External research bodies have conducted research and monitoring activities measuring crayfish distribution, abundance, biomass, fecundity and recruitment at Rottnest. The outcome of one of these surveys showed a significant increase of abundance, size class and biomass of *Panulirus sp*. within the Sanctuary Zones.

### Management strategies

In 2007, the high use levels of the reserve and concerns over impacts of associated activities on the ecological sustainability of the marine environment prompted the development of a Marine Management Strategy (MMS). A key feature of the MMS was the increased application of no-take areas. From 1 July 2007, the zoning plan included the extension of two existing sanctuary zones and the creation of three new sanctuary zones. In total the two amended and three new sanctuary zones now cover 663 hectares or approximately 17 per cent of the reserve waters.

Furthermore, the MMS established a monitoring and research program within the Marine Reserve to monitor biodiversity and abundance of species and extend our knowledge of marine management including social research. This was to be achieved both by external research organisations and by developing capacity within the Rottnest Island Authority. A review of the MMS was required in 2009-10 with the aim of assessing the program and refinement of the measurable outcomes. Additional funding for the implementation of the MMS has been set aside in the new RIMP from 2010-11 onwards.

Cockburn Sound

# Practical experiences with monitoring: the Cockburn Sound story – monitoring for a purpose

Dr Tom Rose

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Cockburn Sound and Owen Anchorage are some of WA's most popular and valuable coastal marine embayments. For example, it was recently estimated that over 200,000 boat visits were made to the sound over a recent summer. These numbers are considered conservative and may be much larger. They indicate the level of popularity these embayments have for WA's population. Cockburn Sound, Owen Anchorage and their catchments and foreshores also have asset values close to $50 billion and provide an annual contribution to WA and the national economy of approximately $10-15 billion. Regardless of the numbers, Cockburn Sound is under enormous environmental and physical pressure from recreation, developments, fishing, commercial and defence shipping, industrial inputs (mainly from historical contamination), as well as from urban drainage.

## Context for environmental reporting

Reporting on the environmental health of Cockburn Sound is difficult because of its history and wide range of multiple uses. Measuring current impacts or identifying emerging contaminants of concern and separating them from the influence of significant seagrass loss to the ecosystem in the 60s and 70s (>78% of seagrasses lost), industrial contamination, urban growth and general nutrient enrichment is not a trivial exercise.

Reporting on the environmental health of the Sound is a legal and policy mandate outlined in the *State Environmental (Cockburn Sound) Policy 2005*, referred to as the SEP. Reporting though can actually be considered a more easy task than that required to fund, organise, coordinate, analyse and interpret the results of a number environmental monitoring programs required to address the SEP.

Cockburn Sound Management Council (CSMC, now with the Department of Environment and Conservation – DEC) was created in April 2000 following over two decades of environmental controversy and community demands to create a management body for this valuable and popular coastal embayment. In 2005, the first and only State Environmental Protection (Cockburn Sound) Policy (SEP) was gazetted under the Environmental Protection Act (1986). This gave the CSMC coordination, monitoring, advisory and reporting powers. The CSMC is an advisory body to the Minister for Environment under the Environmental Protection Act (1986). Responsibility for Owen Anchorage was gained in 2004 while the SEP (2005) was being finalised. This policy and two accompanying documents on Environmental Quality Criteria and Standard Operating Procedures (2003_04) gave the CSMC a scientific basis to assess environmental data and grade environmental health as defined by four major environmental values and related objectives. It is complimented by the ability of the CSMC to co-opt data and coordinate environmental monitoring in the Sound. This is further supported by its Cabinet endorsed Environmental Management Plan (2005) that enshrines monitoring and reporting strategies.

## Environmental report cards

As part of its annual reporting requirements the CSMC produce a three colour coded traffic-light report card that grade performance on six major environmental quality objectives based on over 30 environmental and physico-chemical parameters. They form the basis of its annual Environmental Report Cards. A green code means things are 'good' and to maintain monitoring, yellow indicates environmental quality guidelines have been exceeded and the CSMC should investigate why, while red indicates that an environmental quality standard has been exceeded. A red code requires formal notification to the Minister and negotiation with the party(s) deemed responsible as to how and when they will address the exceedance. Overall, the environmental report cards underpin the CSMC's annual *State of the Sound* Report which is given to the Minister and tabled in Parliament.

## Monitoring

Every year the CSMC outsources three environmental monitoring contracts. They are the backbone to its environmental reporting. They are for water quality monitoring in Cockburn Sound which measures physico-chemical and some biological parameters including phytoplankton near aquaculture facilities and for aquaculture health. It also repeats this water quality monitoring for Owen Anchorage. Lastly, it funds an annual seagrass health monitoring program that ranges from control sites in Warnbro Sound moving northward through Shoalwater Bay and Cockburn Sound and then into and across Owen Anchorage. Water quality monitoring covers approximately 27 sites in total, including two reference sites in Warnbro Sound. Seagrass monitoring covers up to 27 sites within approximately 20 locations set at various depths. These programs are run during the summer and early autumn to ensure the most naturally variable portion of the year, i.e. during winter and spring, are avoided.

Once every three to five years the CSMC commission monitoring programs to look at indicators or parameters that address environmental health that can be done infrequently but regularly over time. These kind of sampling programs are done for contaminants in sediment and water, imposex or for other infrequent investigations that the community or the CSMC feel are necessary to improve knowledge and understanding of the system. Examples include geomorphic investigations of grey sands in Owen Anchorage, groundwater movement and environmental risk along Cockburn Sound foreshores, benthic habitat mapping, causeway influences on water circulation and fish stress biomarkers (CSMC have done over 18 technical studies in the past nine years). Occasionally the CSMC enter into meta-projects or partner wide-ranging studies that provide insight into Cockburn Sound and its environment. For example, studies on heavy metal content in recreationally popular fish and managed aquifer recharge in karstic limestone areas. These investigations are usually resource constrained and can be politically driven, but are invariably informative.

In terms of issues and experiences with this range of monitoring programs and reporting, most relate to ensuring their objectives align with the CSMC's core purpose to reliably and accurately report on the environmental health of the system. Otherwise focus is on whether environmental quality objectives are being met and that Cockburn Sound and Owen Anchorage remain healthy and are sustainably used for the future of the WA community. Issues include whether sampling is spatially and temporally comprehensive enough, targeting the right parameters, maintaining quality assurance and control, and, whether methods can be adapted to adjust to changing needs. One of CSMC's biggest concerns is to ensure that it does not mislead the community, government and stakeholders when we report on the environmental health of the sound and anchorage.

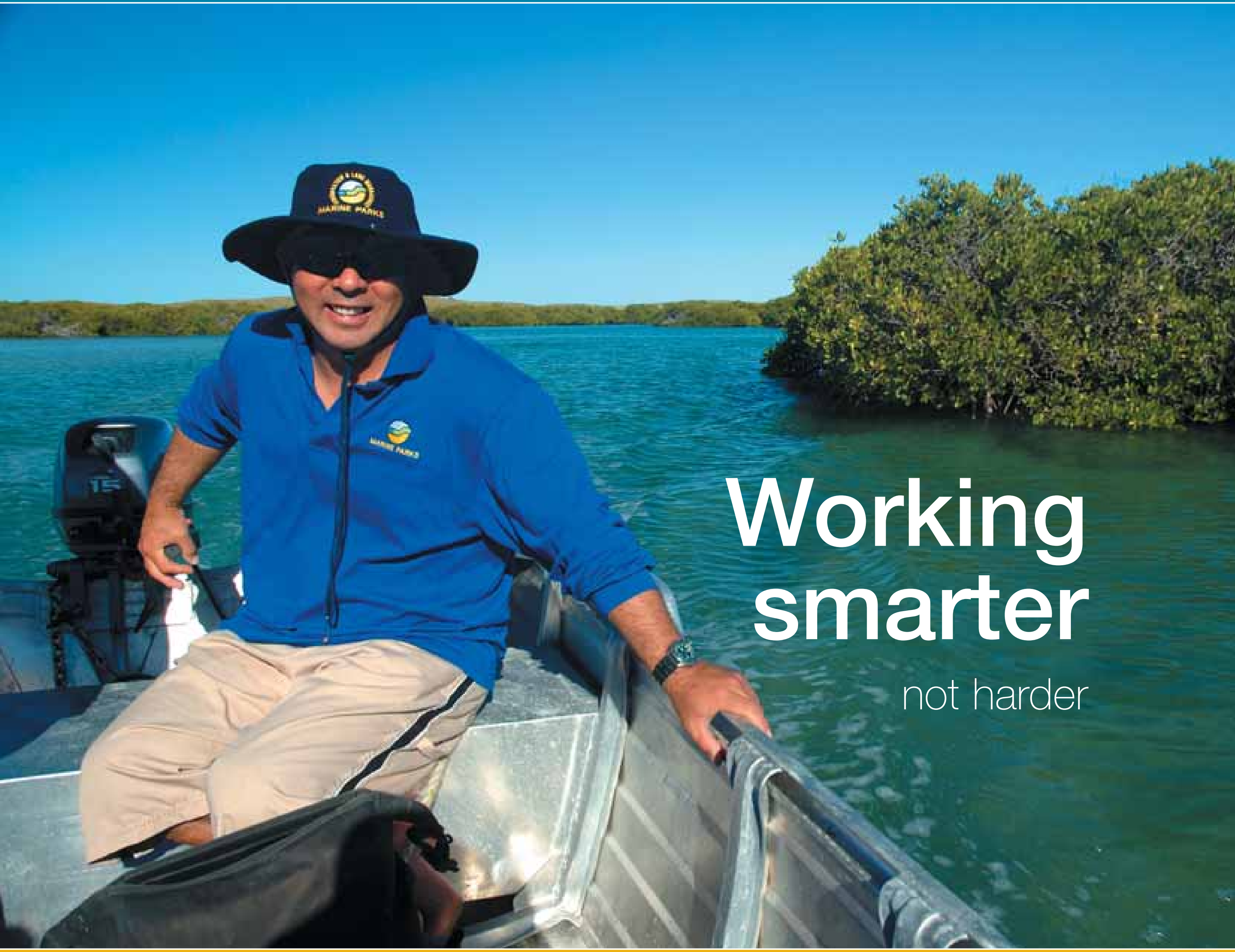
The CSMC can only do this work if its advice is based on sound and meaningful environmental monitoring. It needs to have partnerships with a range of institutions and parties to adequately cover and study relevant investigations into the ecosystem of Cockburn Sound. To answer questions on the environmental health of Cockburn Sound requires monitoring to be comparable, at times innovative, quality assured and importantly, flexible and adaptable to changing needs, issues and questions.

*Researchers monitor the health of Cockburn Sound.*
*Photo courtesy of Cockburn Sound Management Council.*

Session 4

# Working smarter

## not harder



*Kevin Bancroft monitors the marine environment. Photo courtesy of DEC.*

# Current national initiatives in marine and coastal monitoring


Ian Cresswell

**Dr Ian Cresswell**
*Science Director*
*CSIRO Wealth from Oceans flagship*
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### Bridging the policy science interface in marine and coastal monitoring and reporting: Work underway under the Marine and Coastal Committee

The Marine and Coastal Committee (MACC) is one of a number of advisory committees that provide advice to all Australian governments on natural resource management (NRM) issues of national or regional importance. MACC's role is to input on key national marine and coastal matters to the Natural Resource Management Standing Committee (NRM agency heads) who in turn advise the Natural Resource Management Ministerial Council (NRMMC). To facilitate this input, MACC has a number of working groups, including the Intergovernmental coastal advisory group (ICAG), the Biodiversity working group (BWG) and the R&D working group (R&DWG).

In 2008 a report prepared for the NRMMC entitled 'A national approach to addressing marine biodiversity decline' highlighted a number of areas for action for policy makers and managers across the different jurisdictions if Australia is to slow the rate of decline in marine biodiversity. Subsequently a key focus for both the BWG and the R&D WG is to assist and advise on the implementation of the recommendations of this report. In particular, the R&D WG has been requested to co-ordinate and advise on monitoring and reporting activities, working towards a national approach to reference sites, reporting structures and information, including environmental indicators.

This presentation will outline the process being undertaken by MACC to progress this initiative. This includes a cross-jurisdictional expert workshop held in July 2009, progress of a newly established taskforce in developing the framework, a national set of reference sites and common indicators, and pilot studies to demonstrate the functioning and value of such a national approach.

*Researchers working on climate change at a WAMSI climate change research symposium. WAMSI's project leader for this research is Dr Ming Feng (right). Photo courtesy of CSIRO.*

# Constructing historical timelines – is it worth the trouble?

Kevin Bancroft

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The Department of Environment and Conservation (DEC) is coordinating the development and implementation of a statewide integrated marine monitoring, evaluation and reporting (MER) program focussed on measuring the effectiveness of departmental marine conservation and management programs. The initial focus of the Western Australian Marine Monitoring Program (WAMMP), as it is called, is on assessing the condition, pressures and management response on biodiversity assets within WA's marine protected areas and threatened marine fauna.

Key complementary elements of the WAMMP are the development and implementation of standard methodologies to ensure datasets in the future are comparable in time and space and the construction of historical timelines from existing data to extend our understanding backwards in time. Historically, marine MER programs in WA have been undertaken by State and Commonwealth Government agencies, universities, community groups and industry. Some of these programs extended over decades but many were 'one-off' or undertaken for short periods (i.e. a few years) in localised areas with specific purposes in mind. As a result, the programs were often developed with limited consideration of broader goals, historical data or future needs. Furthermore, the indicators and methodologies used in different programs to measure the condition of the same asset (e.g. live coral cover) were often different and, in some case, changed through time.

Despite these constraints, historical marine MER programs in WA have produced a wealth of data over the past three decades. These data can potentially be used to increase the temporal and spatial understanding of historical patterns and trends in asset condition in relation to natural, anthropogenic and climate change pressures on the marine environment. Furthermore, the development of indicators and standard methodologies, currently underway in DEC, must be informed by appropriate historical data if these data are to be used in the way described above and complement datasets from future DEC marine MER programs.

The initial steps in the construction of historical timelines will be the development of a methodology to assess the utility of historical datasets of the marine environment of WA. This presentation will summarise progress to date.

*Kevin Bancroft monitors the marine environment. Photo courtesy of DEC.*

## The power of historical datasets

# A demographic approach to monitoring the current and future health of coral communities?

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*The new bioresources library was set up in early 2009 to house coral specimens and samples of other species. Pictured at the launch were WA Museum technician Oliver Gomez, Chair of the WAMSI Board, Dr Peter Rogers, and WA Museum curator Dr Jane Fromont. Photo courtesy of WA Museum.*

*One of the new coral species being found by researchers off WA's coast. Photo courtesy of C.Bryce/WA Museum.*

This work aims to supplement some of our current long-term monitoring of coral communities on WA reefs. These data currently include changes in percentage cover, community composition and coral size-structures, mostly under background conditions or in response to natural and/or large-scale disturbances. We are investigating the utility of linking changes in community composition and population structure to the underlying changes in the life cycle of target coral species. The coral life cycle was first divided into six stage classes and one or more methods used to investigate the transition of individuals through these stages. Stage transitions are: 1) larval supply and recruitment, and growth and survival of 2) juvenile, 3) small adults and 4) large adult colonies. The life cycle is closed by linking reproductive output and larval dispersal to larval supply and recruitment. The mean rates of transition through the stages are summarised as the population Vital Rates and incorporated into a simple conceptual model based on Life Table Response Experiments (Caswell 1989). Populations of common species with contrasting growth forms (branching, massive) are investigated over several annual time-steps in which conditions are mostly likely to be classified by a period of calm, or by levels of physical (e.g. coral bleaching, cyclone) or biological (disease, predation) disturbances. For each site and year, vital rates and population statistics are interpreted relative their environmental conditions, and related to changes in population structure and community composition. Population statistics include an estimate of whether the population will increase of decrease in size, the relative importance of stages to population growth, and the susceptibility of stages to different disturbances. The vital rates are also combined with population structures to project changes under ongoing conditions, or to explore how relative changes in different transitions can influence population growth and structure in the future.

This work is currently in the analysis stage. To date, vital rates and population statistics have varied as expected among sites and environmental conditions, and provided valuable insights into the future consequences of disturbances. Additionally, different methods investigating the same part of the life cycle have produced similar results. However, variance around parameter estimates was often large and was multiplied when incorporated into the model, highlighting the importance of providing measures of variance when reporting demographic data. The large variance around some parameter estimates resulted in non-significant differences among stages, traits, locations or years, despite large differences in mean values and empirical evidence supporting a significance difference. Variance was usually largest in populations during times of disturbance, which has implications for the amount of effort required to make comparisons among treatment populations meaningful, and thus, the suitability of this approach to different types of monitoring programs.

## Consistency vs best practice:

# Lessons learnt from a scoping project for long term monitoring

**Dr Brett Human**
*WA Department of Fisheries*

The Coastal and Marine Resource Condition Monitoring-Scoping Project was a 12-month, NRM funded program, focussing on the marine and coastal environments of the Pilbara and Kimberley region, northern Western Australia. The project had three aims: firstly, to undertake a knowledge review and gap analysis of the research and monitoring literature; secondly, to undertake a pilot field study to field trial potential resource condition indicators (RCI), and assess remote sensing as a monitoring tool; and thirdly, to develop a strategic framework for long term resource condition monitoring (RCM).

Project activities included the knowledge review of the research literature, from which knowledge gaps were identified and presented to stakeholders from the region. The stakeholders prioritised the knowledge gaps through a voting process, to identify priorities for future research.

The pilot field study assessed a number of potential RCI's for mangrove and inter-tidal mudflat habitats. Preliminary findings indicate that RCI's that truly reflect resource condition are limited, and even fewer RCI's are available for use when considering practicality and cost efficiency. Remote sensing is a cost effective method for monitoring at large spatial scales and/or in remote areas. Preliminary results from different ground truthing methodologies show differences between the methods, but the differences remain constant between sites. Therefore, consistency of ground truthing methods are needed for the duration of the monitoring program. Monitoring objectives will determine the temporal and spatial scales, and the frequency of monitoring, through the strategic framework being developed. The strategic framework will also provide criteria to assist in selecting appropriate RCI's.

Key findings of the project are that: a significant portion of research and monitoring is conducted by private enterprises and consultancies in the Pilbara and Kimberley; information is generally not accessible and there is very limited data sharing between all parties involved in RCM, and this is a significant impediment to the progress of RCM in the Pilbara and Kimberley region, and elsewhere; the relative research and monitoring effort is low compared to elsewhere in Australia; and there is a paucity of baseline data of resource condition.

The project has identified areas of need in RCM programs. These include better storing and access to natural resource condition data and datasets. There is also currently no mechanism in place to implement many long term RCM programs.

*Department of Fisheries researchers at work. Photo courtesy of the department.*

## Practical constraints? Strategic monitoring and compliance monitoring

# Monitoring fish biodiversity: What can the fish tell us?


Dr Tim Langlois

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A key question for marine managers is how the status of the marine environment will respond to interventions, either through use or through management. It has been recognised that a variety pressures can impact fish biodiversity including climate change, fishing and other human uses. We need to develop metrics of biodiversity and ecosystem function that will be sensitive to predicted changes in these pressures and can be easily communicated.


*Dr Langlois in the field.*

Univariate statistics generally provide models with less sensitivity to small changes in assemblage structure than those based on multivariate data. However, multivariate analysis of the assemblage data represent how fish biodiversity responds to multiple environmental pressures simultaneously, whereas monitoring programs may wish to focus one only one of these pressures.

Here, a multivariate model of the relationship between fish assemblages (sampled at eight locations across south-western Australia) and sea surface temperature (SST) was generated using a canonical analysis of principal coordinates (CAP). This approach provides an initial predictive framework of fish assemblage structure with changes in SST, whilst acknowledging that substantial intrinsic heterogeneity from unmeasured factors remains. Species turnover along the canonical gradient in SST can then be investigated using univariate models of individual taxa. We also demonstrate how data from monitoring programs can be compared to the multivariate model using control chart techniques.


*Audio-visual fish monitoring at Two Rocks. Photos courtesy of Dr Langlois.*

# Managing long-term datasets: ensuring data stays 'alive'

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Managing long-term research datasets comes with a range of unique issues that are manageable if the correct planning and resources are given to data management. Broadly speaking, data management is anything outside of actually using the data and the first step is having a data management plan. This is a must before starting any monitoring program and just like a getting a tattoo, if you are not careful you may end up with an unwanted result.

Depending on whether you are storing your data at an institutional or subject repository, below are some issues to consider when implementing a long-term monitoring program. These include:

a. metadata procedures,

b. overview of database design,

c. data entry, verification, and editing (QA/QC),

d. responsibilities for tasks,

e. how data will be accessible and to whom,

f. storage and back-up strategy – off-site copies,

g. procedures for migration to new technology, and

h. budget for ongoing data management.

Once the program is under way it is important to ensure that others are aware of the program to aid in collaboration and reduce duplication. National initiatives now under way are the Australian Ocean Data Network (AODN) and Australian National Data Service (ANDS) that can assist in the management of marine monitoring data to ensure data is discoverable and accessible.

This presentation will outline some key points to ensure your data stays 'alive' and will refer to the flow chart 'Strategic Plan for Monitoring' used on the day.

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