





The Western Australian Marine Science Institution (WAMSI) has become one of Australia's premier marine research organisations.

Its structure is special: a collaboration of 15 State, Federal, industry and academic entities cooperating to deliver benchmark research and independent, quality scientific information.

They are providing collaborative research across disciplined biodiversity teams, helping with coastal planning, developing fisheries ecosystem understanding, and assisting the conservation and management of our valuable marine estate. This regional scale research will ensure marine industries such as the oil and gas industries, tourism, fisheries and aquaculture co-exist with the environment, and facilitates future planning and engineering needs accompanying increased community coastal use and development.

By joining forces to become WAMSI, these organisations are able to use their collective strengths to carry out research into climate change, fisheries ecosystems, oceanic scale changes, marine life and future effects of drivers of change.

Marine ecosystems everywhere are facing pressures from new and expanded coastal communities and the demands of industries.

Preliminary findings show sea levels around some parts of WA's coast are rising, the iconic western rock lobster industry is being affected by climate change as are many aspects of marine life as sea temperatures increase.

WAMSI research is finding ways to predict the effects of climate change years in advance, and providing new information towards identifying why rock lobster numbers are dwindling. Researchers have found new species of sponges, sea urchins and kelp, some potentially with medicinal anti-cancer properties. Thousands of samples of yet to be named species are now being stored at the new WA Marine Bio-resources Library, supported by WAMSI. Other researchers have created future scenarios to show what marine life and the ocean environment could be like in 10, 20 and 50 years' time.

WAMSI is highly responsive. It can deliver timely research answering the big questions while working with its stakeholders – industry, the Indigenous community, the general community, governments, academia and decision-makers.

It has been rated as an outstanding success by its partners and stakeholders with initial State Government funding of \$21 million escalating to \$87 million as other organisations support the depth and strength of collaborative research.

More than 250 scientists are working on 86 WAMSI research projects covering ocean forecasting, biochemistry, new marine species, estuaries, sustainable fisheries, marine biodiversity, conservation best-practice and the effects of ocean movements on engineering structures. The scientists have been joined by some of WA's best postgraduate students allowing WAMSI to provide some of the finest post-tertiary marine educational opportunities in Australia.

WAMSI is confident that the quality science being provided will ensure that society enjoys the best of both worlds – sustainable ecosystems and best practice industry.

I hope you enjoy reading about the achievements and preliminary findings of our work in this short report.

Dr Peter Rogers

Chairman of the Board Western Australian Marine Science Institution

WAMSI's research is divided into three themes – ocean forecasting, biodiversity conservation and natural resource management.

There are six nodes of research. They are:

- **Node 1:** WA shelf and coastal marine ecosystems;
- **Node 2:** climate change processes, predictions and impacts in a warming Indian Ocean;
- Node 3: conserving the marine state: best practice management and underpinning science management and conservation of marine parks: Ningaloo Marine Park;
- **Node 4:** sustainable ecosystems for sustainable fisheries;
- **Node 5:** marine biodiscovery, biotechnology and building a WA marine bioresources library; and
- **Node 6:** ocean science for offshore and coastal engineering.

Strategic research on Western Australian shelf and coastal marine ecosystems

Extensive science-based fundamental knowledge of our ocean processes is needed as the state's population grows and the variety and level of demands placed on marine and coastal ecosystems increase.

The scale of proposed uses, together with the rate of climate change, means the impacts on the marine environment are much less predictable than in the past.

As a result, governments, industry and the community face bigger, more frequent and more rapid decisions relating to marine and coastal planning. Enhancing their ability to do so urgently requires greater strategic understanding of our ocean environment.

WAMSI provides the science that is needed to underpin confident and well-informed decision-making by improving how we predict and assess the way ecosystems respond to man-made and natural pressures.

WAMSI's partner, CSIRO's Wealth from Oceans National Research Flagship, is working with the Australian Institute of Marine Science (AIMS), Geoscience Australia, Murdoch University, Edith Cowan University, The University of WA, the WA Department of Environment and Conservation, the WA Department of Fisheries, the Chemistry Centre of WA and the WA Museum to undertake this research.

RESEARCH PROJECTS INCLUDE:

- characterising the WA coastal marine ecosystem structure and function and enhancing our capacity to understand, predict and assess ecosystem response to man-made and natural pressures;
- understanding how ocean currents transport nutrients and fish and rock lobster larvae over a variety of distances and time scales;
 - identifying the source of nutrients that maintain productivity in near-shore ecosystems, and how the nutrients are utilised, then transferred between marine plants and animals;

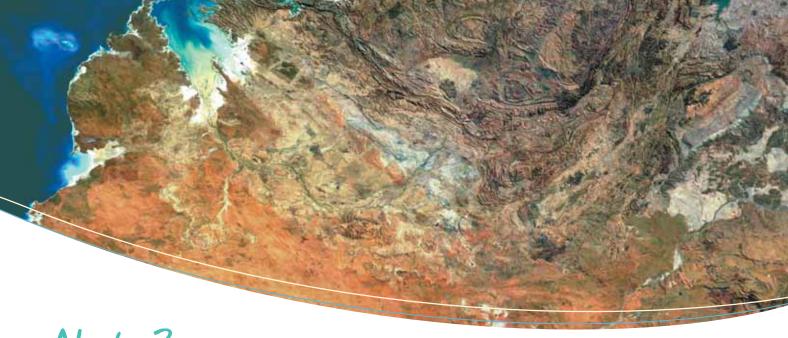
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- determining what factors affect the distribution of marine animals and plants in different habitats and how these communities are affected by natural and man-made disturbances;
- evaluating the effectiveness of marine protected areas by comparing the ecological interactions within and external to the protected zones;
- investigating and simulating how ocean waves influence coastal marine habitats;
- developing visualisation tools that make data and the results of scientific research more accessible to decision-makers; and
- assessing near-shore habitats in the Kimberley region of northern WA for coastal development planning.

PRELIMINARY FINDINGS

- The discovery of extensive deep water kelp beds in more than 50 metre depth off south-west WA has reinforced the importance of kelps to primary production.
- The importance of recycling of nutrients on the continental shelf for primary production has been established with about 84 per cent of nitrogen used in primary production being recycled here.
- Connectivity studies have shown important zones of strong offshore dispersal and zones of strong retention along the WA coastline. This has important applications in designing marine protected areas and managing fish stocks, as well as potentially helping predict the path of oil spills.
- The importance of waves in driving the speed and direction of currents in coastal lagoons has been determined, as has the role they play in structuring habitat patterns and the distribution of animals and plants. Waves are also important in resuspending nutrients trapped in seabed sediments, making them available for plant growth.
- The size and age of marine protected areas are key factors in them being successful conservation measures. Small reserves appear to provide no measurable benefit and reserves may take a long time to provide any measurable conservation benefits.
- Researchers have explained the autumn chlorophyll bloom that appears off the west coast of WA each year using a new understanding of the dynamics of the Leeuwin current and its eddy systems to explain how deep water nutrients are mixed into surface waters.



Effects and predictions of climate change in a warming Indian Ocean

Changes in ocean temperatures are having far reaching impacts on the WA marine ecosystem.

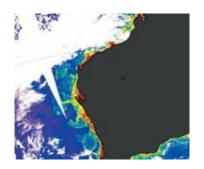
WAMSI Node 2 conducts strategic research in the Indian Ocean and the sub-Antarctic Southern Ocean, upwind from WA in the westerly air-streams.

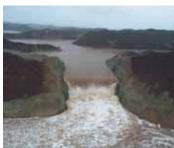
The research identifies links between large scale variations in the ocean and impacts on the marine environment off WA. It focuses on identifying ocean-processes that feed back to the atmosphere and give persistence and predictability to climate anomalies.

Node 2 has three projects with the Bureau of Meteorology, CSIRO's Wealth from Oceans National Research Flagship and AIMS.

RESEARCH PROJECTS INCLUDE:

- identifying large-scale variations in the ocean and its effect on the WA marine ecosystem;
- predicting future changes in the eastern Indian and Sub-Antarctic Southern Ocean and their effect on WA's marine environment;
- projecting climate change signals in the Leeuwin Current;
- assessing the impacts of climate change at Ningaloo Reef;
- forecasting seasonal changes of large-scale ocean off the WA coast;
- identifying ocean-processes that interact with the atmosphere and provide help predict irregular climate events; and
- delivering climate research on a variety of scales, from the entire Indian Ocean and the Leeuwin Current to Ningaloo Reef, ranging from seasonal, inter-annual and long-term changes.





PRELIMINARY FINDINGS

- An enhanced warming trend off WA has been measured and is linked to changes in regional atmospheric circulation.
- The Indonesian Throughflow and Leeuwin Current flow rates have reduced by 25 to 30 per cent since the 1960s – a decline probably caused by more frequent El Niño events in the Pacific in recent decades, and by climate change.
- The Indian Ocean Dipole (tropical Indian Ocean climate anomaly) events can be accurately forecast one to two seasons in advance.
- The strength of the Leeuwin Current can be accurately forecast six months to one year in advance.
- Observation systems have been set up for long term monitoring of the physical environment off the Ningaloo Reef Tract.

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Managing and conserving the marine state: best practice management and underpinning science

Ningaloo Marine Park is one of the most beautiful natural areas in Australia.

Stretching 300 kilometres along the WA coast, the park is in a region where tropical and temperate waters mix to create a unique display of marine life. It is home to at least 250 coral, 500 fish and 600 mollusc species.

WAMSI's partner, the WA Department of Environment and Conservation, manages 15 collaborative research projects across the park.

More than 60 scientists from seven State and Federal agencies and universities are carrying out those projects which will improve our understanding of the biodiversity in the marine park and develop improved tools for its conservation and management.

This research project is an example of where initial government investment has grown through co-investment and interest by the scientific community into a comprehensive and collaborative research effort offering many future benefits. The integration of research findings from the wide scope of research will also provide a 'big picture' view of the marine park, demonstrating the benefits of collaborative effort through institutions such as WAMSI.

RESEARCH PROJECTS (FOCUSSING ON THE NINGALOO MARINE PARK) INCLUDE:

- assessing deep-water communities and habitats;
- assessing the status of target, subtidal invertebrate species such as octopus and lobster;
- establishing protocols to monitor reef health;
- developing our understanding of shark and ray diversity, abundance and distribution, including the local and regional migratory patterns of whale sharks;
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- assessing the ecosystem level impacts of human activities and the effectiveness of current management strategies in conserving the values of the marine park;
- describing the underlying structure of the park including sediments, morphology and growth history of the reef;
- improving our understanding of fish and invertebrate communities, their distribution and response to human pressures;
- assessing the groundwater system and its linkages with Ningaloo Reef;
- describing and modeling how ocean water flows through the marine park;
- developing our understanding of biological oceanic processes including nutrient dynamics across the reef; and
- assisting in the development of a management strategy evaluation model to better understand and assess the implications of pressures on the reef and management actions.

PRELIMINARY FINDINGS

- The deep water areas of the marine park have a rich marine biodiversity including large sponge and filter feeder communities.
- GIS referenced maps are being developed for bathymetry, sediments, geomorphology and seabed texture which will be used to characterise benthic habitats and potential biodiversity.
- The acoustic tracking program has led to the assessment of fish, shark and ray local movement patterns and habitat use within the marine park.
- Clear trends have been detected in fish assemblages from north to south in the marine park.
- Abundance and distribution of some target fish and lobster species are related to historical fishing patterns.
- Water movement across the reef and lagoons is generally wave-driven.
- The wind-driven Ningaloo Current and upwelling provide a temperature buffer to the Ningaloo Marine Park, protecting it from warm water bleaching in summer months.



Sustainable ecosystems for sustainable fisheries

Healthy marine ecosystems are a prerequisite for healthy marine biological communities and healthy fisheries.

Complex relationships between habitat, environmental change, marine biological systems and communities have to be balanced against the needs of people living along the coast.

The aim of this area of research is to ensure marine communities and fisheries can be sustained hand in hand with social and economic use.

RESEARCH PROJECTS INCLUDE:

- the development of a bioregional framework to assist the holistic management of marine resources;
- undertaking a risk assessment of each of the key ecological, economic, social and governance elements within the west coast bioregion;
- examining the value of qualitative modeling techniques to understand the links and impacts of different management actions on social, economic and ecological outcomes;
- analysing long-term commercial fisheries datasets for their potential to monitor ecosystem change;
- investigating indicators needed for long-term monitoring of the effects of climate change and fishing on ecosystems and key habitats;
- identifying suitable sites to monitor long-term changes in ecosystems;
- assessing the value of long term datasets for measuring the impacts of climate change;
- reviewing and assessing the trophic interactions and experimental methods to provide advice on when fishing activities might have a significant impact on ecosystem structure;
- designing and establishing a monitoring and assessment program for new 'closure' and 'nearby fished' reference areas that will be used to examine the impacts of the western rock lobster fishery within deep-water regions;
- monitoring changes in estuarine ecosystems of the Swan River, Peel-Harvey and Leschenault estuaries to ascertain the effects of climate change, human activity and biological factors;
- assessing how to monitor any potential impacts of fishing on key non-target species;
- developing new and more efficient methods to quantify recreational catches;
- undertaking a review of the methods to complete social and economic assessments to assist fisheries management decisions;
- improving our understanding of the main causes of changes in behavior by recreational fishers; and
- assessing the social and economic impact of policy changes on commercial and recreational fishers and the wider community.

PRELIMINARY FINDINGS

- A set of component trees has been developed to outline each of the major components relevant to the management of the west coast bioregion across all the ecological, social and economic elements of Ecosystem Based Fisheries Management (EBFM).
- An agreement has been reached among State Government agencies on the 13 key marine ecosystems within the west coast bioregion.
- A series of qualitative models has been generated to outline the strong links that occur between some of the various ecological, governance and economic elements of fisheries within the west coast bioregion.
- A long term trend has been found for increasing sea temperatures off the lower west coast of WA plus an increase in the frequency of ENSO events which may have affected the population dynamics of some species.
- An assessment of the long term commercial catch data for the west coast bioregion showed no evidence of significant changes in species composition or ecosystem structure during this period.
- The species composition in the Peel-Harvey Estuary
 has been found to be similar to the 1990s, directly
 after the opening of the Dawesville Channel and
 significantly different to the composition before the
 cut. A qualitative ecosystem model has been
 developed for both before and after the cut. It is
 examining possible reasons for these changes.
- The top four most abundant fish species found in the Leschenault Estuary during the present study were also the top four most abundant species found in the 1990s.
- A review has been completed on the appropriate social and economic assessment methods to use for particular situations based on their cost, duration and robustness.

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Marine biodiscovery, biotechnology and aquaculture

An unprecedented focus on the WA marine estate for conservation, medical research and the development of the oil and gas industry is providing an unequalled opportunity for the exploration of marine biodiversity.

WA's pristine and biodiverse oceans – the blue farms – have the potential to offer a wealth of raw, genetic materials to develop pharmaceutical and other biotechnology products.

Already the marine biotechnology industry which is growing at 18 per cent a year is benefitting from the scientific evidence being discovered by WAMSI's research partners. The partners include AIMS, the WA Museum and UWA. The WA Institute of Medical Research is an external partner.

Many of WA's marine species are found nowhere else in the world. From the small number of samples collected on explorations to date, an extraordinarily high 'hit rate' was returned in medicinal areas. One of the samples may be used in screening programs for breast cancer.

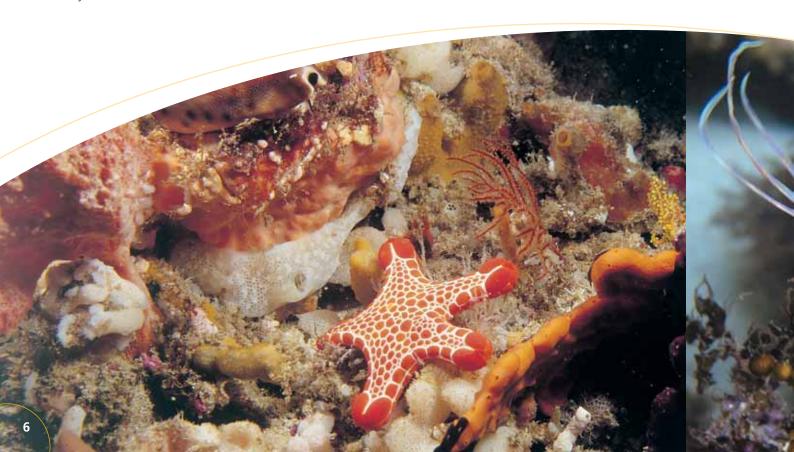
Research has found species of WA's sponges and sea squirts have some of the world's highest rates of antitumour activity while compounds from marine filter feeders such as sponges are being used in cosmetics, medicine, sunscreens, anti foulants and industrial enzymes.

Microbes are at the basis of this research: more than a billion micro-organisms live in each litre of seawater and it is known that microbes dominate the abundance, diversity and metabolic activity of the ocean.

They comprise 98 per cent of the biomass of the world's oceans, supply more than half the world's oxygen, are the major processors of the world's greenhouse gases and have the potential to mitigate the effects of climate change.

They are the cause of diseases that are suspected to be spreading because of global warming yet paradoxically, the compounds they produce are potential cancer cures and solutions for combating human disease.

Scientists are only just beginning to understand the important environmental roles that microbes play in marine systems.





RESEARCH PROJECTS INCLUDE:

- establishing a WA Marine Bioresources Library (WAMBL) through collaboration between the WA Museum and AIMS, storing thousands of marine life samples. This was officially opened in March 2009;
- identifying valuable compounds from marine biodiversity;
- enhancing marine, microbial, chemical and biomedicinal sciences;
- using marine samples in screening programs targeting breast cancer;
- producing marine natural products, including anticancer agents; and
- analysing marine and estuarine bacteria for their 'quorum quenching' compounds which may be able to be used to control bacterial infections.

PRELIMINARY FINDINGS AND ACHIEVEMENTS

A database was created to track frozen samples in and out of WAMBL.

Professional curation by the WA Museum will enable marine extracts to be used by State, national and international organisations.

WAMSI is pursuing the introduction of WA biotechnology legislation to improve biodiscovery research investment and exploration prospects.

AIMS has delivered extracts stored for 25 years to WAMBL.





Ocean science for offshore and coastal engineering

WA's coastal and offshore regions have many types of infrastructure including offshore platforms and pipelines, ports and coastal protection structures.

The design of these structures requires a thorough understanding and prediction of the physical oceanographic processes, particularly under a changing climate.

The waters off WA's North-West coast – 2000 kilometres along the coast from the North West Cape to the Timor Sea and 500 to 600 kilometres offshore – are of national strategic significance and ecological importance.

The region is also home to the offshore oil and gas industry, one of the most significant components of the State and national economies. Thousands of kilometres of oil and gas pipelines have been laid in this area and thousands more are expected to be laid in the future.

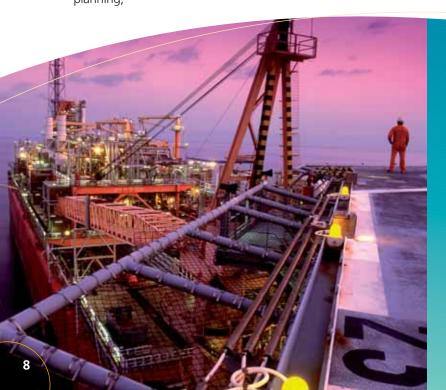
RESEARCH PROJECTS INCLUDE:

- developing databases of long-term wind and atmospheric data for WA under climate change;
- assessing changes to offshore wave fields;
- determining changes in surge magnitude and frequency;
- assessing coastal stability at selected regions under the combined effects of wave fields, storm surges and sea levels rises;
- assessing climate change impacts on coastal and estuarine infrastructure;
- providing research for policy development and planning;

- using field measurements to determine the impacts of offshore internal (sea floor) waves;
- developing high-resolution models of tide dynamics;
- undertaking high-resolution measurements of internal tides in offshore waters;
- predicting large amplitude internal waves (king waves) on the shelf;
- developing numerical models to describe the ocean's response to cyclones;
- developing hindcasting and forecasting tools for the ocean environment; and
- establishing networks and data streams for ocean glider observations.

PRELIMINARY FINDINGS

- Internal shelf waves at several sites on the North-West Shelf have been characterised.
- Laboratory models have been built to study the generation of internal shelf waves.
- Models linking global ocean circulation models with regional scale ocean models have been built.
- Specialised instrument systems to measure high energy turbulent flows in the deeper waters have been built and deployed on the North-West Shelf.
- Ocean gliders have been deployed to obtain near-real time data from the Continental Shelf and slope regions.



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Australian Institute of Marine Science

http://www.aims.gov.au/

Bureau of Meteorology

http://www.bom.gov.au/index.shtml

ChemCentre (WA)

http://www.ccwa.wa.gov.au/

CSIRO – Wealth from Oceans Flagship

http://www.csiro.au/org/WealthOceansFlagship.html

Department of Commerce (WA)

http://www.commerce.wa.gov.au/index.htm

Department of Environment and Conservation (WA)

http://www.dec.wa.gov.au/

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http://www.bom.gov.au/wagoos/

Western Australian Museum

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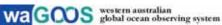






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Node 5: WA Museum/Clay Bryce, ChemCentre WA and AIMS. Node 6: Woodside Energy and UWA

