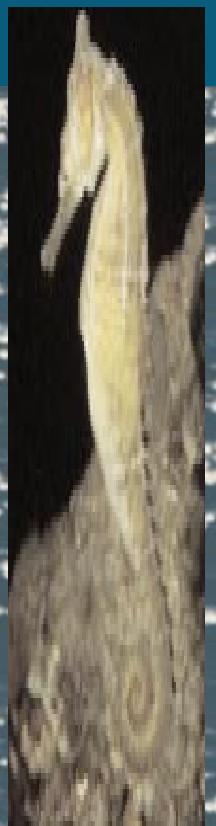
Commonwealth of Australia

Australia's Marine Science and Technology Plan

An Overview



Australia's Marine Science and Technology Plan
An Overview




Inquiries and requests for further copies of *Australia's Marine Science and Technology Plan* and this *Overview* should be addressed to the General Manager, Science and Technology Policy Branch, Department of Industry, Science and Resources, GPO Box 9839 Canberra ACT 2601.

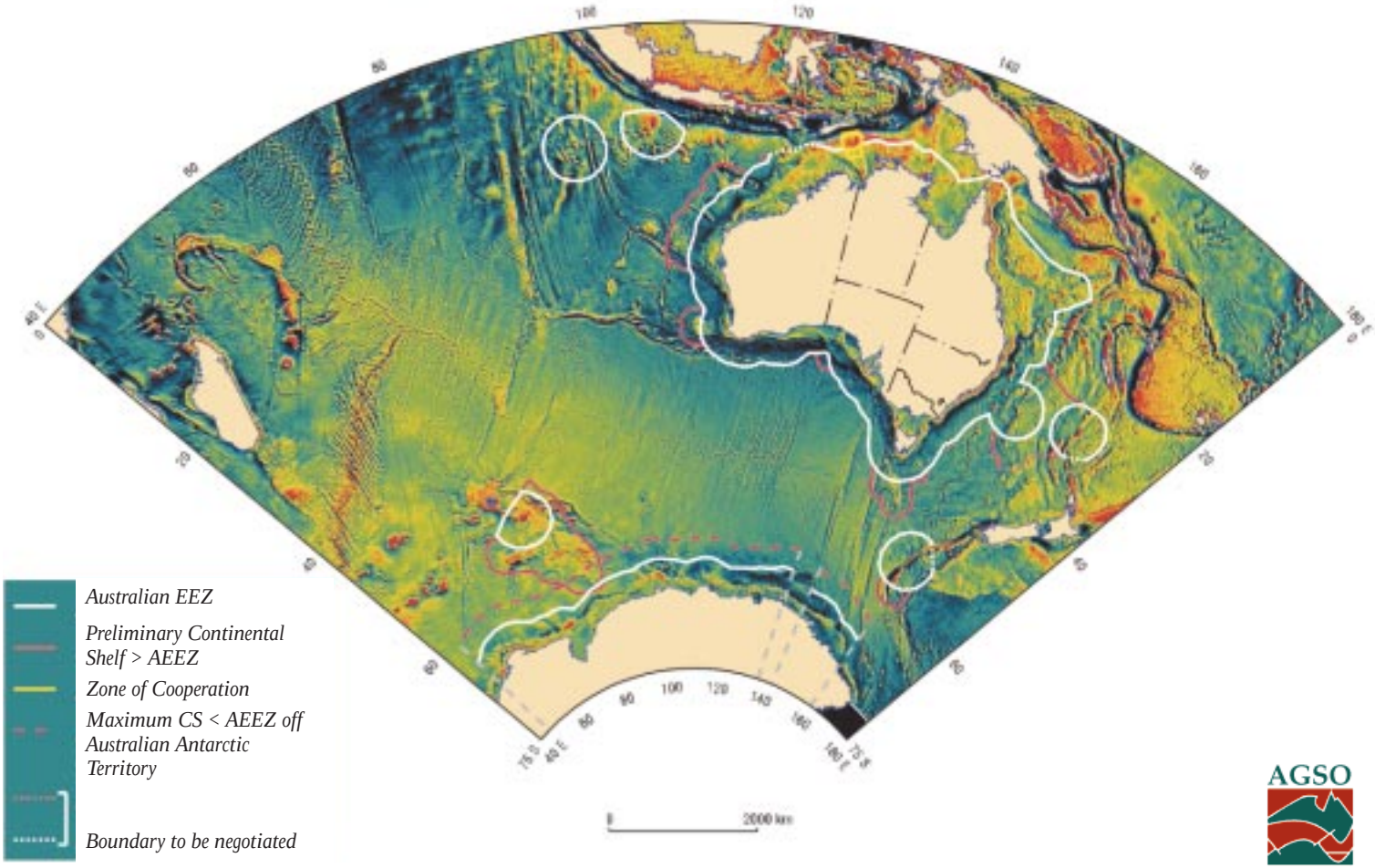
This document is also available on the Internet at http://www.isr.gov.au/science/marine/marineoverview

ISR 1999/080

ISBN 0 642 720371

Design and art production: Design One Solutions, Canberra
Printed by: Goanna Print, Canberra

Australia's Marine Jurisdictional Zones (Preliminary)



Foreword

Australia's Marine Science and Technology Plan presents a vision for the future for our marine research capabilities, and the benefits these can bring to the understanding and sustainable use of our marine environment. The Plan was developed with the assistance of an expert Working Group appointed by the former Minister for Science and Technology, the Hon Peter McGauran MP. The Plan identifies national needs and priorities for our marine science, technology and engineering capabilities, and nominates particular activities relevant to the implementation of *Australia's Oceans Policy.*

The Marine Science and Technology Plan is an authoritative reference document for Government agencies in considering the content of their programs. This *Overview* presents the major issues and conclusions to be found in greater detail in the Plan itself.

The Plan examines what needs to be done for, and by, marine science, technology and engineering to ensure progress in improving our knowledge base, and to ensure sustainable resource use and development, over the next ten to fifteen years. Members of the Marine Science and Technology Plan Working Group have nominated several priorities to be addressed within the next three to five years.

The Plan does not make recommendations, nor is it prescriptive on matters of funding.

Australian marine science and engineering research is conducted by a large number of Federal and State Departments and agencies, by Universities and university-linked consortia, and by maritime industries. As with Australia's science system as a whole, this pluralism is both necessary and desirable, to ensure that the most appropriate skills and knowledge are developed and made available locally. *Australia's Marine Science and Technology Plan* recognises the importance of continuing independence in research and program planning, while encouraging collaborations and ongoing communication. The Plan provides a coherent framework for future directions in marine research in the national interest.

I am grateful to the members of the Marine Science and Technology Plan Working Group for the considerable thought and time they have devoted to presenting a complex set of issues with clarity, and in a well structured form.

I and my colleagues, particularly those who are members of the National Oceans Ministerial Board, welcome the opportunity that the Plan affords to consider these issues.

I encourage the participation of all Australians in developing a greater national understanding of our marine environment, and an increasing appreciation of its contribution to our national well-being.

Nick Minchin
Minister for Industry,
Science and Resources
June 1999.

A VISION FOR AUSTRALIA'S OCEANS

(Australia's Oceans Policy)

Healthy oceans: cared for, understood and used wisely for the benefit of all, now and in the future.

A VISION FOR AUSTRALIA'S MARINE SCIENCE AND TECHNOLOGY

Strong and vigorous marine science, technology and engineering, informing national marine policy and decision-making, and contributing fully to knowledge, to skills development, and to the health and wealth of the nation.

GOALS FOR THE MARINE SCIENCE AND TECHNOLOGY PLAN

Australia's Marine Science and Technology Plan provides:

- a strategy for integrated and innovative science and technology, conducted in the national interest to guide the exploration and ecologically sustainable development and management of the marine resources under our jurisdiction, to understand and predict climate variability and change, and to guide the development of sustainable maritime industries;
- a key to a better understanding of the marine environment and its living, mineral and energy resources; and
- an effective framework for well focused, concerted action in both the short and long term by the Australian marine science, technology and engineering community, adding value by creating opportunities for significantly increased cooperation.

Executive Summary

Australia's ocean environment is vast. Our Exclusive Economic Zone (EEZ) covers 11 million square kilometres. The EEZ around the mainland, at 8.6 million square kilometres, is larger than Australia itself (7.8m sq km); while the EEZ off the Australian Antarctic Territory (AAT) embraces a further 2.4m sq km.

Beyond the EEZ, our Legal Continental Shelf off the mainland and AAT extends for an estimated further 5.1m sq km. Under the United Nations Convention on the Law of the Sea (UNCLOS), we have the opportunity to confirm a claim to this area by 2004. Together with the EEZ, the combined total area of 16.1m sq km is known as Australia's Marine Jurisdiction (AMJ).

Australia's Marine Science and Technology Plan is concerned with developing a better understanding of the nature of the AMJ:

- to understand the form and structure of the seabed;
- to understand the ocean's thermal characteristics, current patterns and chemistry, and its role in our weather and climate;
- to understand our marine species and ecosystems, and their behaviour over time;
- to assist environmental conservation; and
- to support the ecologically sustainable long term planning and management of our marine resources and environments.

We need to meet these challenges in a region that encompasses all types of ocean temperature zones, from tropical to polar, and an extensive and diverse range of ecosystems and species, many of which are unique in the world. We also need to respond to the diverse needs of users of our waters, and guide the development of sustainable maritime industries in the context of ecosystem-based and multiple-use management regimes. The resources needed for this include:

- a skills and knowledge base with which to build understanding;
- accurate and detailed geoscientific, oceanographic, biological and ecosystems information;
- the means to gather and analyse this information, including refurbished and additional research infrastructure; and
- improved data management capabilities to permit integration and expansion of nationally important data sets.

Our marine science, technology and engineering capabilities are characterised by a degree of specialisation that puts us at the forefront of certain fields, from knowledge of tropical reef ecosystems to fast vessel design and construction. We are building our knowledge of regions and using this in a range of applications – conservation and environmental protection, offshore petroleum exploration and production, navigation guidelines, shipping, and sustainable fisheries resource management programs.

The Plan builds on these strengths in presenting proposals for integrated and innovative science and technology, conducted in the national interest to guide the exploration and ecologically sustainable development and management of the marine resources under our jurisdiction; to understand and predict climate variability and change; and to support the sustainable development of existing and new marine industries. It also addresses our ability to meet our international commitments, and the need to encourage effective community participation, including through the integration of indigenous knowledge in understanding and managing marine resources.

The Plan defines twenty-nine objectives for the national effort in marine science, technology and engineering, through three Programs:

1. Understanding the marine environment;
2. Using and caring for the marine environment; and
3. Infrastructure for understanding and utilising the marine environment.

The objectives, and particular strategies for achieving them, arise from a review of national circumstances that included consideration of the issues and programs identified in *Australia's Oceans Policy*, released by the Minister for the Environment and Heritage, Senator the Hon Robert Hill, in December 1998.

The Plan takes a long view. Its proposed responses to national issues, needs and priorities are intended to be addressed over a period of ten to fifteen years, although within that period, some proposed actions and initiatives are identified as priorities for consideration in the shorter term – over the next three to five years. These are:

- complete the mapping, data interpretation and processing required to define our AMJ boundary, in time for lodgement with the UN Commission on the Limits of the Continental Shelf by November 2004;
- continue to map the form and nature of the seabed, and collate and digitise seabed data sets, commencing in the South East Region in support of the Oceans Policy's South East Regional Marine Plan;
- develop an integrated southern temperate research program, linking State-based and Commonwealth research organisations to improve knowledge and sustainable resource use, and to support the Regional Marine Planning process;
- develop a multidisciplinary northern tropical research program, focused in the Torres Strait/Arafura/Timor Sea Region;
- strengthen and increase the marine science skills base, to give us the capacity to learn more, and to respond to expected increased future demands from coastal and marine industries;
- upgrade the Research Vessels *Franklin* and *Southern Surveyor*, and extend their days at sea as National Facilities;
- improve national capability and reduce recurrent research costs by:
  - acquiring a domestic deep water swath mapping capability;

  - refurbishing existing and establishing new island research stations; and
  - providing new hydrodynamics facilities for the design and testing of offshore platforms and high speed vessels;
- implement an Australian Ocean Observing System (AOOS), designed to improve marine observing capability, links between existing facilities, and to support our participation in international oceanographic and meteorological observation programs such as the Global Ocean Observing System (GOOS);
- coordinate the linking and management of nationally important data sets, and their enhancement, by establishing a new National Marine Data Group, serviced by a secretariat in the Australian Land Information Group (AUSLIG), with links to the Heads of (Commonwealth) Marine Agencies, the Australian Spatial Data Infrastructure and the Australia and New Zealand Land Information Council (ANZLIC); and
- monitor and report on the implementation of issues identified in the Marine Science and Technology Plan, through a new Marine Science Advisory Group, whose core membership is drawn from agencies in the Industry, Science and Resources (ISR) portfolio, with secretariat support from that Department.

Contents

Introduction

The Purposes of *Australia's Marine Science and Technology Plan*

Australia's Marine Science and Technology Plan has been developed by an expert Working Group with support from the Department of Industry, Science and Resources. Its content is informed by a number of previous reports, consultation with experts, comment from Government Departments, and by over 140 submissions that have been put to the Working Group over the past two years. The Plan's time in development is a testament to the complexity of issues that it has addressed.

The structure of the Plan reflects three major, long-term priorities for marine science, technology and engineering, which give rise to its three Programs:

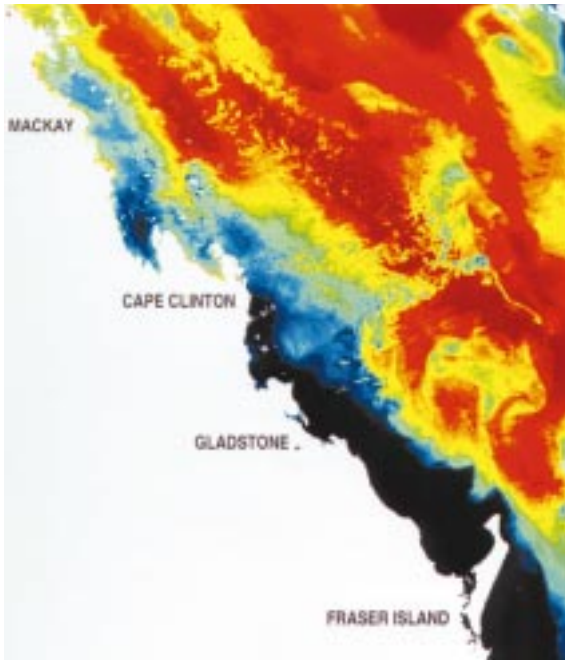
1. Understanding the marine environment;
2. Using and caring for the marine environment; and
3. Infrastructure for understanding and utilising the marine environment.

Through the Programs, the Plan:

- provides an overview of the national research effort in marine science, technology and engineering, and provides a coherent framework for the future;
- addresses existing and emerging priorities for marine science, technology and engineering;
- identifies a range of issues for consideration by Commonwealth and State-based organisations in formulating their programs over the next ten to fifteen years; and
- supports *Australia's Oceans Policy* in its emphases on ecosystem-based management for sustainable multiple use of regional resources, and the development of Regional Marine Plans.

The Programs encompass twenty-nine Objectives, each of which identifies needs and priorities, and strategies for responding to these. Some of these needs are being addressed already, through government programs, research programs of organisations and universities, industry R&D, and in programs involving community participation. Strategies proposed as responses to further needs will require planning for implementation in the future. The Plan's priorities are intended for address in the shorter term, over the next three to five years.

Readers with an interest in particular aspects of the Plan can contact a range of "Principal Organisations" identified as being active in the areas addressed by the Plan's Objectives. While the Plan identifies constraints, it also celebrates success: there are a large number of Representative Projects illustrating activities being undertaken around Australia, by universities, industry, and State and Federal government research agencies. These "windows to research" offer an extraordinary range of insights into activity from deep water geoscience, to cone shell toxin analysis, to aquaculture. This *Overview* features similar highlights.



Furthermore, the Plan proposes ways to keep in touch with the national research effort, to ensure continuing response to the needs of the environment, and our marine industries, and to maintain and strengthen our research capabilities. It is a Plan that is intended to encourage change, and to be changed itself.

The Context of *Australia's Marine Science and Technology Plan*

Australia's Marine Jurisdiction

Australia's Marine Jurisdiction (AMJ) is approximately 16.1 million sq km in area – one of the largest marine jurisdictional zones in the world. As a party to UNCLOS Australia has sovereign rights to explore, exploit, conserve and manage the natural resources within its EEZ; subject to lodging a claim with the UN by 2004, we can confirm further rights and responsibilities to the limits of the Legal Continental Shelf beyond the EEZ boundary.

These responsibilities include the protection and ecologically sustainable management of the ocean and its resources on the basis of best available scientific information.

We know very little about the nature of the AMJ. Our knowledge of the shape and composition of the seafloor is limited, because much of it is unmapped and unsampled. The ocean moves in complex patterns, and it varies in its temperature, affecting our weather and marine ecosystems in ways we are just beginning to understand. The ocean's chemical structure retains many secrets. The creatures of the sea, from micro-organisms, to the shrimp-like krill, to larger fish species including those that are staples in our diet, play roles in marine food webs and ecosystems that change with stages in their life cycles, and are not well understood. Our offshore petroleum industry, supplying 90% of our output, is drawing its product from less than 4% of the EEZ. We do not know how many more petroleum basins remain to be discovered.

The task of improving our knowledge and understanding of the marine environment is an enormous, complex and exciting challenge. In areas where we are economically and socially active, this understanding is vital to the protection and maintenance of our marine ecosystems, the ecologically sustainable use of our fisheries and coastal areas, and the growth of existing and new marine industries. In areas we are just beginning to explore, gaining knowledge of deeper ocean geography, geology, and ecosystems presents issues that require sophisticated technological solutions.

Australia's Oceans Policy

Australia's Oceans Policy sets in place the framework for integrated and ecosystem-based planning and management in all of Australia's marine regions.

It promotes the ecologically sustainable development of our ocean resources, and encourages the continuing development of internationally competitive marine industries, while ensuring marine biological diversity protection.

At the core of the Oceans Policy is the development of Regional Marine Plans, based on large marine ecosystems.

The first Regional Marine Plan will be developed for the Southeast Region. This includes waters off Victoria, Tasmania, southern New South Wales and eastern South Australia. The Regional Marine Plan's boundaries will not be extensions of State lines, but will be determined by ecological and geographical characteristics. Within this area lie some of our more important fisheries, petroleum provinces, and tourist destinations. It is an area used intensively by shipping, and it is offshore to our largest population concentrations. The development of a Regional Marine Plan for this area will require the support of existing research findings and new studies in all of these areas of concern. *Australia's Marine Science and Technology Plan* proposes strategies to build the information base supporting the development of this and future Regional Marine Plans.

Implementing *Australia's Marine Science and Technology Plan*

Australia's Marine Science and Technology Plan will be implemented by Federal and State/Territory Government Departments and research agencies, by universities and museums, by industry, and by community groups. This will happen over time and as circumstances, including financial capacities, permit.

The Plan suggests a focus of effort to priorities that are identified for each of the 29 program Objectives, and a particular shorter-term focus to those more immediate priorities outlined in the Executive Summary.

The formation of an expertise-based, Ministerially appointed Marine Science Advisory Group, is supported by secretariat services from ISR, proposed as a means to monitor and report on progress in the Plan's implementation. The Group, comprising a core of three advisers drawn from within ISR's portfolio science agencies: the Australian Geological Survey Organisation (AGSO), the Australian Institute of Marine Science (AIMS), and the

Commonwealth Scientific and Industrial Research Organisation (CSIRO), with additional members co-opted on a needs basis, would:

- monitor the implementation of *Australia's Marine Science and Technology Plan*, ensuring its continuing relevance and responsiveness to change;
- facilitate coordination between all parties undertaking activities consistent with the Plan; and
- at the request of the Minister, report on progress in implementing the Plan, provide advice on science issues relevant to the effective implementation of the Oceans Policy, and report on other matters as required.

The Minister would report progress in implementing the Plan to the National Oceans Ministerial Board, of which he is a member.

A new "public good" Marine Resources Research and Development Corporation could enhance the coordination and implementation of the Plan's Programs. Through five Programs, the Corporation could augment, and facilitate links between, marine research programs conducted by groups across Australia. Based on priorities outlined in the Plan and the Oceans Policy, the Programs suggested are:

1. Marine biological diversity and ecosystem processes;
2. Physical, chemical and geological attributes, including the role of the ocean in climate change and climate variability;
3. Information for resource and conservation management;
4. Long-term development of skills and infrastructure; and
5. Communication and Administration.

The Programs

Program 1: Understanding the Marine Environment

Goal: To characterise and improve our understanding of the Australian Marine Jurisdiction, including the coastal zone, and the adjacent ocean; the ocean's interaction with the atmosphere; and, within the AMJ, the ocean's biological resources, ecological systems, and underlying geological features.

Objective 1	To characterise and better understand the geological framework and evolution of Australia's continental margin and adjacent ocean basins
Objective 2	To map the form and nature of the seabed of Australia's Marine Jurisdiction
Objective 3	To define the boundaries of Australia's Marine Jurisdiction
Objective 4	To improve understanding of the principal physical and chemical oceanographic processes in Australia's coastal and open ocean waters
Objective 5	To improve predictions of Australian climate variability and change by understanding the role of the oceans in the climate system
Objective 6	To understand marine biodiversity and biological processes in Australia's oceans
Objective 7	To understand the dynamics of Australia's marine habitats and ecosystems

Program 1

Understanding the Marine Environment

Program 1 of the Plan deals largely with basic and long-term strategic research.

Australia's marine zones are characterised by complex physical, chemical, geological and biological processes, and by the interactions among those processes. There are also the complex sea-air-land interactions. These processes are little understood, yet developing an understanding is integral to planning for conservation and sustainable use.

While short-term applied research is appropriate for particular case studies and projects, basic and long-term strategic research is necessary if we are to generate the sufficient knowledge base that we need to better understand and manage our marine heritage.

Geological Knowledge

The level of knowledge of the dynamics and resources of the earth's crust throughout the AMJ is highly variable. The greatest knowledge is in those areas that have been subject to exploration for petroleum and minerals, and those for which swath mapping data is available.

To develop the knowledge base and reduce risk in resource exploration, Australia needs to continue to explore its continental margin, to define and describe the characteristics of the seabed and underlying material, and to participate in related international programs, for example, the Ocean Drilling Program and its successors.

Seabed Mapping

Fundamental to the efficient development of our offshore industries, exploration, defence and conservation is accurate information on the form and nature of the seabed, its benthic ecosystems, and an understanding of the processes operating at and below the seabed. For the majority of the AMJ the form and nature of the seabed is poorly known.

The Marine Science and Technology Plan responds to these concerns by identifying three main strategies:

- acquire a domestic deep water swath mapping capability, and implement a systematic program of swath mapping, sampling and data digitisation;
- acquire and collate existing but currently dispersed bathymetric data sets for the seafloor, and digitise their information in a nationally agreed common format; and
- continue to develop rapid and cost-effective marine habitat assessment techniques, including through an expanded capacity for swath mapping the continental shelf.

Swath mapping is conducted by multibeam sonar, is some 50 times faster than conventional bathymetric mapping, and (with sampling to ground-truth the swath data) provides 100-150 times more information.

The Oceans Policy is focused strongly on the development of Regional Marine Plans for large marine domains whose sizes and resources will be determined on a biogeographic basis. Seabed swath mapping would provide biogeographic information important not only in developing an understanding of the regions themselves, but to the process of defining the boundaries between Regions.

AMJ Boundary Definition

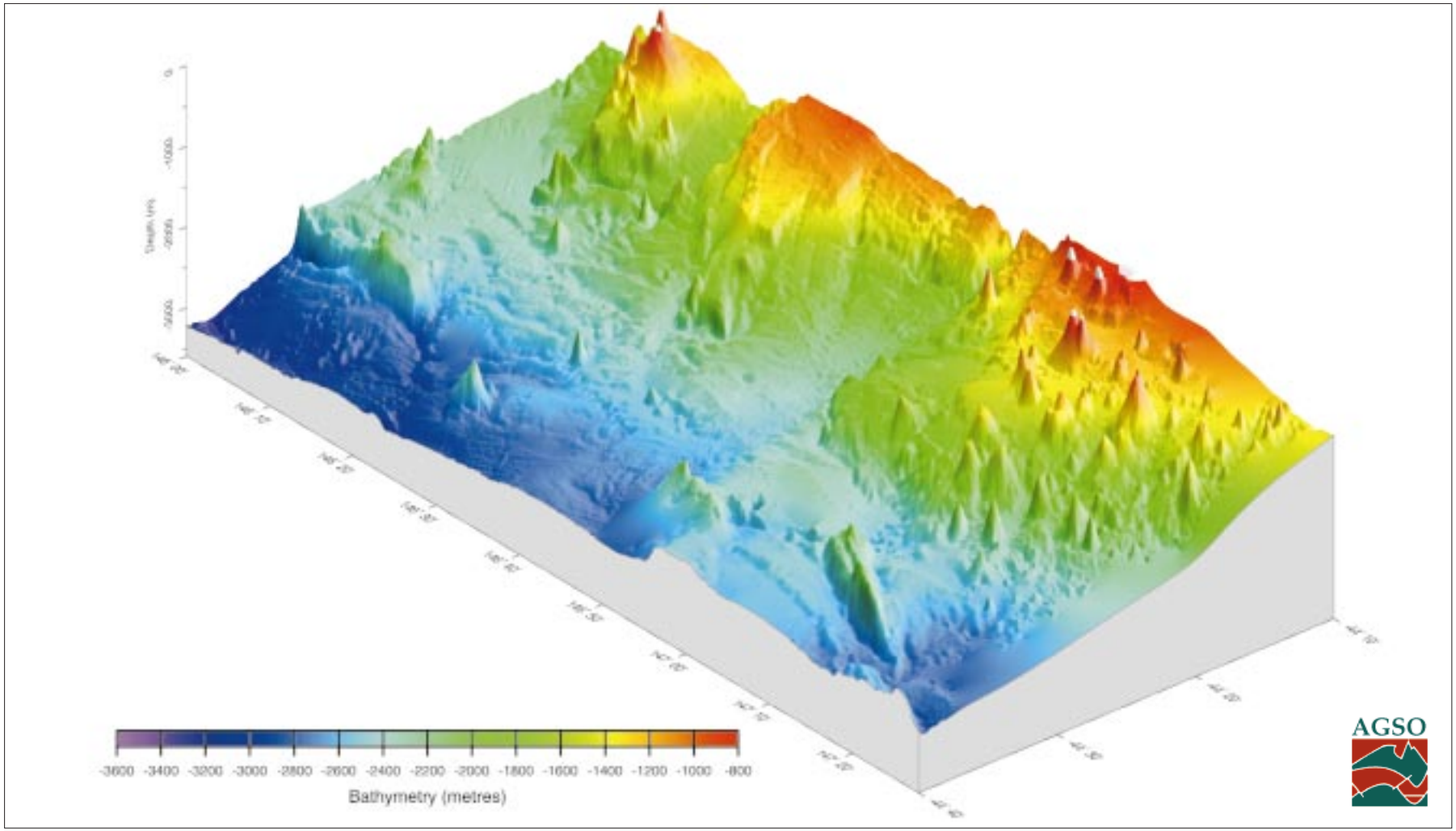
The AMJ covers several areas where the Legal Continental Shelf (LCS) extends beyond the EEZ around the mainland, certain islands such as Lord Howe Island, and off the coast of the AAT.

The Oceans Policy and the Marine Science and Technology Plan emphasise the need to complete the definition of the AMJ boundary, including determination of the physical and geological characteristics of the LCS, in time for lodgement with the UN Commission on the Limits of the Continental Shelf by November 2004.

Remaining survey work off Macquarie and Lord Howe Islands, and interpretation and processing of data from these and prior surveys, will complete the definition of the AMJ boundary around the Australian mainland. This work is regarded as a priority, as is work to define and document the limits of the AMJ boundary beyond the EEZ of the AAT. A decision concerning the AAT project will need to be taken in the near future.

Understanding of Oceanographic Processes

All management decisions relevant to the coastal regions, the AMJ and the adjacent oceans require an understanding of physical and chemical


-3600 -3400 -3200 -3000 -2800 -2600 -2400 -2200 -2000 -1800 -1600 -1400 -1200 -1000 -800
Bathymetry (metres)
AGSO

processes. These processes control the health of ecosystems, the distribution and concentration of natural and introduced chemicals and strongly influence the use of the oceans for recreational and commercial benefit. To maximise environmental and economic benefit to Australia, we need comprehensively and quantitatively to describe, understand and model the physical and chemical processes in the marine environment.

An understanding of the processes of ocean circulation and weather, and the translation of this information into predictive forecasts, is important to the safety and efficiency of commercial and recreational vessels, to search and rescue, and responses to marine pollution, including trajectory modelling of oil and chemical spills.

The area of chemical oceanography is probably one of the least well represented of the major marine disciplines. The paucity of chemical baseline data and knowledge of processes limits our understanding of natural chemical pathways, and the fate and behaviour in the marine environment of toxicants, heavy metals, nutrients and organics.

Priorities for consideration are to:

- resource the Research Vessels *Franklin* and *Southern Surveyor* to conduct more extensive oceanographic research, and spend more days at sea;
- develop multidisciplinary studies and models at a range of scales from coast through EEZ to the adjacent oceans; and
- develop a comprehensive and quantitative description of the physical and chemical processes within Australia's coastal and deeper waters, through accurate spatial and temporal measurements and by integrating chemical data.

The Role of the Oceans in the Climate System

Climate variability and change is a major factor in future planning for all sectors of the Australian economy. Oceanographic research is a significant element of climate change research. The oceans play a key role in determining long term patterns of rainfall, which in turn affects our agricultural productivity and water resource planning.

It is important to continue the collection and analysis of data from ocean sediments, corals and Antarctic ice cores as indicators of past climates and climate variability, and enhance our participation in international climate change research programs. Our data, and our ability to collect further data on Southern Hemisphere oceanographic complexities, is vital to the further development of global predictive models. Challenges are to:

- develop and implement a program of seasonal to interannual climate predictions;
- understand decadal variations in ocean structure; and
- estimate the timing and regional impact of climate change, including changes in the frequency of the El Niño Southern Oscillation (ENSO) phenomenon and changes in the capacity of the Southern Ocean to absorb carbon dioxide.

Marine Biodiversity and Biological Processes

The high biological diversity and the many different marine ecosystems under Australian jurisdiction together represent one of the richest marine biotas on earth, and are valuable national assets.

We have a particular responsibility to improve our knowledge of the flora and fauna within our marine jurisdiction. There are two major reasons for this. Firstly, there is a high degree of endemism (species found nowhere else) and diversity in our temperate waters; and secondly, Australian tropical marine systems are reservoirs of biodiversity in the threatened Indo-West Pacific region (a world centre for marine biodiversity). New and better information on biological diversity at the genetic, species, ecosystem and regional levels is needed for:

- sectoral resource management that protects marine ecosystems;
- integrated and ecologically sustainable management of multiple ocean uses; and
- the development of management response plans to implement improved strategies for environmental protection, conservation and sustainable development.

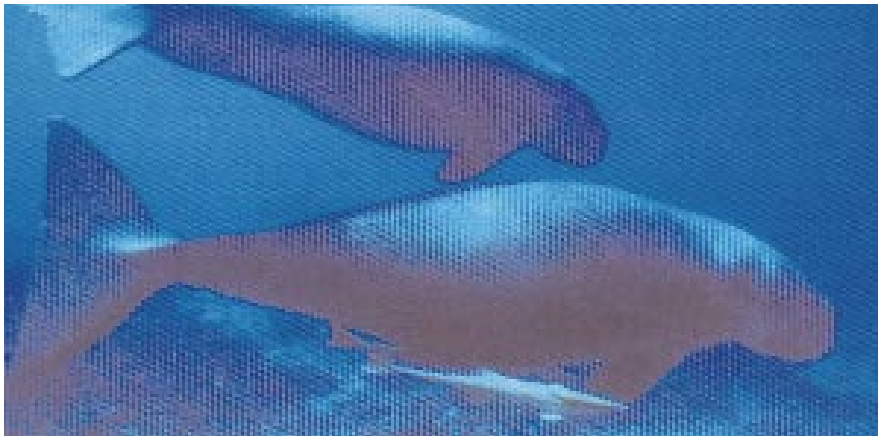
However, current levels of knowledge for marine biological diversity and biological processes, and the distribution, abundance and impact of introduced marine organisms, are inadequate for effective conservation action, posing risks for marine biodiversity and the survival of species, habitats and the ecological processes on which they depend.

The Oceans Policy will provide funding to support rapid marine assessments of biodiversity in developing Regional Marine Plans and identifying new areas for inclusion in the National Representative System of Marine Protected Areas.

The Plan supports these initiatives, and identifies further strategies for possible implementation in the longer term. Chief among these is the maintenance of existing, and the establishment of new, long term monitoring programs that would collect region-specific data in interrelated areas, including ocean temperature, chemistry, and biodiversity. A priority for biodiversity assessment purposes is to improve the limited size and usage of our taxonomic research capability.

Initiatives meriting further consideration include the following:

- develop an integrated southern temperate research program, with new or refurbished infrastructure as required, to link and strengthen Commonwealth and State-based research organisations in southern Western Australia, South Australia, Tasmania, Victoria, and southern New South Wales, to improve geoscientific, species and ecosystems knowledge and sustainable resource use, and to support the South East Regional Marine Plan; and
- develop a new northern tropical research program, focused in the Arafura/Timor Sea region and the Torres Strait, to improve understanding of ecosystems and species, to support and integrate traditional knowledge; to support the sustainable development of our fisheries, pearling and petroleum industries; and to support bilateral agreements with Indonesia and Papua New Guinea.



Ecosystem Dynamics

All ecosystems are dynamic. Their elements are naturally variable and in a state of flux within limits or trends that are, under normal conditions, characteristic of each system. While change is expected, we need a continuing capacity to distinguish between natural and human induced changes in the marine environment. Maintenance of ecosystem integrity is vital to biodiversity conservation, continued access to high quality resources and amenities, and accommodation of the full range of community aspirations.

Australia's Marine Science and Technology Plan proposes new regional integrated scientific surveys and infrastructure to assess biodiversity and ecosystem dynamics, which would use a series of indicators of ocean environmental health and integrity developed under the Oceans Policy, and be undertaken in the context of a continuing program to complete a systematic mapping and exploration of marine ecosystems in the AMJ.

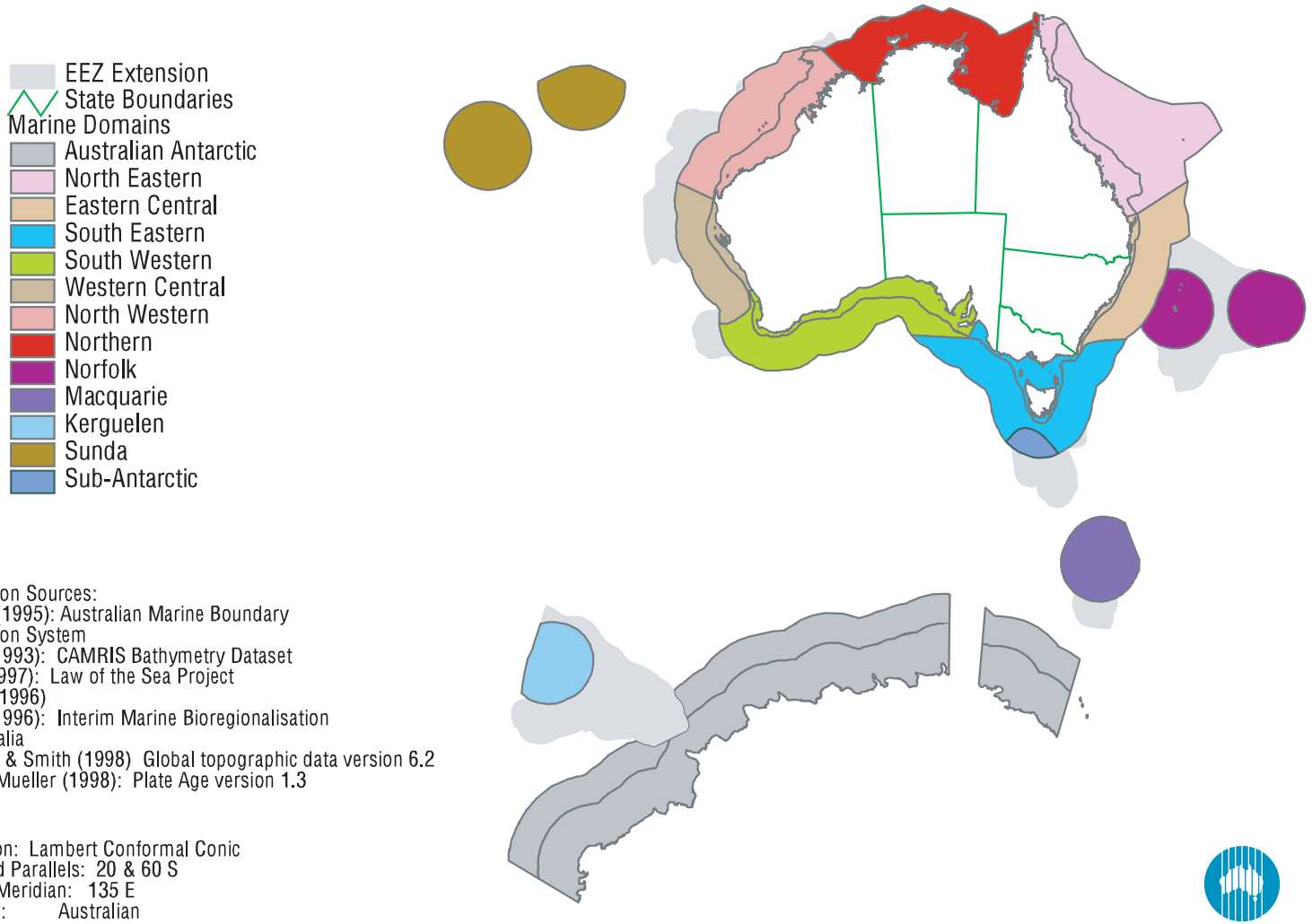
Targeted multidisciplinary studies could include:

- the little-known pelagic systems; and
- coastal areas of high conservation and biodiversity value, such as estuarine systems, seagrass habitats, wetlands, and lagoons.

"A lack of knowledge of our marine ecosystems, their functioning and interactions is the greatest barrier to developing the huge economic potential of the resources of the oceans in a way that protects marine biodiversity and maximises resource utilisation. Rectifying this shortcoming will require the harnessing and development of our knowledge base on all parts of the marine environment – including the sea-floor, the water column and the coastal zone as well as on the living and non-living resources contained within them. Marine science and technology is fundamental to ensuring the right management strategies are adopted."

Our Sea, Our Future, The State of the Marine Environment Report (SOMER, 1995).

Large Marine Domains of Australia's EEZ



Information Sources:
AUSLIG (1995): Australian Marine Boundary Information System
CSIRO (1993): CAMRIS Bathymetry Dataset
AGSO (1997): Law of the Sea Project
GEBCO (1996)
CSIRO (1996): Interim Marine Bioregionalisation for Australia
Sandwell & Smith (1998) Global topographic data version 6.2
Dietmar Mueller (1998): Plate Age version 1.3

Projection: Lambert Conformal Conic
Standard Parallels: 20 & 60 S
Central Meridian: 135 E
Ellipsoid: Australian

Reference: Vincent Lyne

Version 1.03
10 November 1998

CSIRO
MARINE RESEARCH

Program 2: Using and Caring for the Marine Environment

Goal: To provide the knowledge base to support marine industry development, and the ecologically and economically sustainable use and management of the Australian Marine Jurisdiction, including the coastal zone and adjacent ocean and their resources, in the light of increasing development and environmental pressures, and change and variability in the marine environment.

Objective 1	To ensure the maintenance of healthy and properly functioning ecosystems, through the development and application of effective monitoring and assessment procedures and sustainable management practices
Objective 2	To improve understanding of the impact of land-based human activities on the marine environment
Objective 3	To provide the scientific basis for the planning and implementation of sustainable multiple use management practices in our marine environment
Objective 4	To apply knowledge of the oceans' variability and change, including interaction with the atmosphere and sediments, to the management of marine and terrestrial industries and environmental issues
Objective 5	To define, research and explore regions in the AMJ that are potentially important to the petroleum and minerals industries
Objective 6	To improve the productivity and sustainability of wild harvest fisheries, and to improve understanding of the relationship between fished stocks and the ecosystems that support them
Objective 7	To improve the sustainability, productivity and environmental performance of aquaculture
Objective 8	To strengthen the technological base supporting the continued development of a world competitive, specialised shipbuilding industry
Objective 9	To ensure that shipping and allied transport operations can be carried out efficiently, safely and with minimum practical adverse effect on the marine environment
Objective 10	To promote the potential of new and emerging industries, services and technologies
Objective 11	To increase our knowledge of the potential renewable energy in and near Australia's oceans
Objective 12	To strengthen the information base supporting ecologically sustainable coastal and marine tourism and recreation
Objective 13	To develop a collaborative understanding of the marine resource use, management practices and maritime knowledge of Aborigines and Torres Strait Islanders
Objective 14	To assist the security of Australia's Marine Jurisdiction, and to improve the safety of passage within it
Objective 15	To understand and document the implications of marine law and policy for the application of marine science and technology to the utilisation and management of our marine resources

Program 2

Using and Caring for the Marine Environment

Our success in developing the economic potential of our oceans' resources, in a way that protects biodiversity and maximises sustainable resource utilisation, will depend on the strength of our marine science, technology and engineering and its linkages to the needs of users.

We need improved understanding of ecological processes, baseline assessment and monitoring of ecosystem health, knowledge of the individual and cumulative impacts of human activities on ecosystems and their components, and basic research that supports ecologically sustainable marine industry development and growth.

Together, *Australia's Oceans Policy* and *Australia's Marine Science and Technology Plan* bring a new emphasis to the benefits to be gained from a coordinated and integrated approach to ecosystem based, regional multiple use management of our marine resources, building on existing sectoral arrangements, while maintaining and improving ecosystem health.

Australia is competitive by world standards in many marine industries. Current strengths include the designing and building of high-speed ships and ferries, environmental management, tourism, fisheries management and aquaculture.

Our marine industries have been growing strongly over recent years. Marine industries now contribute more to Australia's economy than the nation's agricultural sector. In fact, the economic contribution from our marine resources is growing more quickly than our total economy. Estimated marine industry earnings grew from $10.8 billion in 1984/85 to $41 billion in 1995/96, or an average of 12.7% per year. In the same period, growth in Australia's Gross Domestic Product (GDP) averaged 3.3% per year. Marine industries contributed 3.7% of GDP in 1984/85, and grew to 9% of GDP by 1995/96. An important element in that growth was marine tourism, which was worth $5.9 billion in 1987/88, and grew to $23 billion in 1995/96.

New industries, in areas such as marine biotechnology, instrumentation technology, technology-intensive services, and renewable energy sources, are emerging and have the potential to make significant contributions to the health and wealth of the nation.

Continued advances in marine science, technology and engineering are needed to ensure sustainability in the growth of one of our most valuable and fastest-growing groups of industries.

Ecosystem Health and Functioning

Our knowledge and understanding of mechanisms that govern the behaviour of the majority of Australian marine ecosystems are poor. The paucity of geographically comprehensive and long-term scientific information makes it difficult to assess the condition of our marine environment, to identify trends and to design and assess management programs. To have confidence that use of resources is sustainable and that ecosystems maintain their health, productivity and functionality, national environmental indicators are needed that distinguish 'natural' variability and trends in ecosystems from change caused by human activity.

Planning for continuing human activity requires good information. Proper mapping and monitoring is

necessary to develop a national resource for facilitating coastal planning decisions, reducing uncertainty for industry, and increasing certainty for conservation objectives. We need also to improve our understanding of land-sea interactions and the role these play in ecosystem dynamics. In this

"Following clearly agreed and articulated policy objectives, Australian marine science and technology will provide the necessary essential data and advice to ensure sustainable wealth generation and healthy environmental management of the AMJ. In achieving this, Australian marine science and technology will demonstrate its critical national purpose, promote excellence and innovation and communicate effectively with the public, industry and government. Australian marine science and technology will become the backbone to the nation's economic prosperity."

Australia's Ocean Age, Report to PMSEC (1995).

regard, there is a strong case to develop an integrated approach to land, freshwater and marine research, monitoring and management. A truly comprehensive monitoring and information system should integrate economic and social data to maximise its usefulness as a management tool.

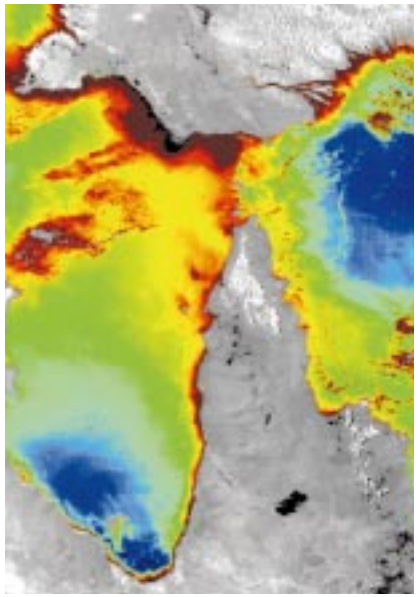
Monitoring natural variability and change in marine environments, and the effects on these environments, could target:

- introduced marine species, loss of habitats, and harvesting of marine resources;
- the introduction of pollutants and chemical agents; and
- cycling of toxicants and nutrients between the water column, sediments and biota.

We should continue to identify vulnerable species, habitats and communities, and assess the utility of policies and programs in sustaining and restoring biodiversity, including fisheries.

Impact of Land-based Human Activities on the Marine Environment

If we are to develop our capacity to minimise the impacts of land-based human activities we need to understand the linkages between terrestrial and marine ecosystems, how these links vary in space and time, and what environmental processes govern change.



At a national scale, the largest source of land-based inputs – nutrients, sediments and leachates – to the marine environment is from agricultural activities. At a local scale, the inputs from coastal cities and towns are significant. At both scales, priority needs to be given to determining sources, developing and applying water quality standards to assess the relative importance of different inputs to different marine environments, designing cost effective methods to minimise the most significant inputs, and evaluating the success of these measures.

Australia's Oceans Policy includes a Government commitment to developing national marine and estuarine water quality standards.

Support for Planning and Implementing Multiple Use Management Practices

Many competing activities take place in our oceans. These activities interact with one another and the ecosystem.

Through *Australia's Oceans Policy*, the Government is committed to integrated ecosystem-based planning and management for multiple uses of our oceans, while retaining existing sectoral management arrangements. Four fundamental principles – ecosystem integrity, wealth generation and resource use, equity, and participatory decision making – underpin multiple use management, which involves recognising, and considering in decision-making, the full range of uses and their impact on marine ecosystems.

Adoption of multiple use management will require a regional capacity for

resource assessment, involving integrated scientific research support.

Because ecosystems have complex dynamics, scientific support for decision making must include both explicit treatment of uncertainty, and the development of robust adaptive management strategies that link monitoring observations to the decision process.

The following initiatives would assist effective multiple use management:

- the scientific definition of ecological regions for multiple use management, including extension to the AMJ's deeper water areas of present coastal bioregionalisations;
- identification of both the benefits and impacts of use;
- protection of biodiversity and ecosystem integrity; and
- the development of means to evaluate alternative management strategies.

Knowledge of the Oceans' Variability and Change

Coastal conditions of humidity, salinity and storms affect both onshore and offshore structures. For safety, cost-effectiveness and environmental protection, coastal and offshore structures and surface and sub-sea vessels must be designed to cope with prolonged exposure, extreme events and long-term change, and to operate efficiently in a marine environment that presents constant variation in its physical and chemical characteristics.

Working in the marine environment requires the support of accurate observational data on wave, current and wind forces. Such data assist prediction of extreme events, the risks and environmental consequences of oil spills, and the application of design standards. They can also be used to replicate natural conditions in marine engineering testing and design facilities.

It will be important to:

- develop a climatology of ocean conditions in strategic locations;
- continue observations of ocean conditions for use in predictive modelling, including modelling of impacts; and
- incorporate new data in engineering for coastal and offshore construction, and vessel design.

Petroleum and Minerals Industries

Petroleum is Australia's highest value offshore resource industry, with 90% of our oil and gas production being sourced from offshore areas. In 1996 the value of offshore oil and gas production was around $8 billion, with exports valued at around $5 billion.

Currently production comes from just 1% of the AMJ, principally the Gippsland Basin and parts of the North West Shelf and the Timor and Arafura Seas. It is estimated that a further 45% of the AMJ contains sedimentary basins that may have the potential to contain commercial petroleum accumulations. However, geological knowledge sufficient to indicate

Identifying Hydrocarbon Seepage on the North West Shelf

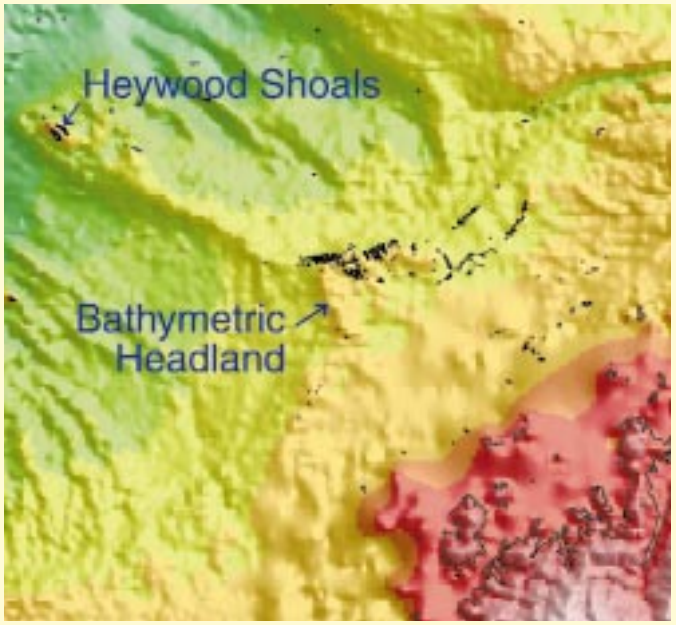
A study of natural and anthropogenic hydrocarbon seepage on the North West Shelf has been carried out by AGSO. This study has used multiple remote sensing technologies, one of which is satellite-based RadarSat Synthetic Aperture Radar (SAR). SAR data detect oil seepage via the calming effects of the seeping oil as it reaches the sea surface.

SAR data through the area of the inner Browse Basin has revealed that this region is characterised by massive, natural oil seepage through porous rock. This seepage tends to be clustered in two areas:

- a localised band of seepage directly associated with the Heywood Shoals, a prominent carbonate bank in the area; and
- a sinuous band in the central part of the region around a major change in the slope of the seafloor, which is referred to as a 'bathymetric headland'. AGSO's seismic studies have shown that this headland, and the oil seepage itself, is related directly to an area where regional Early Cretaceous shales (which normally overlie the porous rock and 'seal' or trap the migrating hydrocarbons in the subsurface) are absent. The most prolific hydrocarbon seepage is actually at the edge of the basin system.

These observations have very important implications for both petroleum exploration and environmental management. For example, the observation concerning seepage volume at the basin edge leads to a conclusion that such areas may represent the best (and most cost-effective) locations in which to capture a 'snap-shot' of the present-day hydrocarbon migration across a margin. In very large, frontier petroleum provinces, where the presence or absence of an indication of migrating hydrocarbons is the key exploration risk (such as in the Great Australian Bight or the Lord Howe Rise), such areas are the first places in which to focus a remote sensing program.

Similarly, these areas are the most likely areas in which unique eco-systems associated with hydrocarbon seepage are likely to be present. Numerous studies have shown that large biological communities, typically comprised principally of carbonate, can colonise the region around seafloor hydrocarbon seeps. These communities actually live on the seeping hydrocarbons. The Heywood Shoals area is one example where unique and little understood seafloor communities have established themselves around zones of active seepage.



From this finding, it is clear that knowledge of natural seepage is important as baseline information for environmental monitoring purposes, in relation to any future resource developments in the North West Shelf region.

AGSO

potential petroleum accumulations is not available for the majority of this area.

Exploration in those areas is expected to increase as the results of the broad-scale baseline research programs conducted by AGSO become available.

Australian industry is noted for its development and deployment of innovative technological solutions to contain costs in developing remote, relatively small petroleum fields. This innovative approach is expected to continue with continuing expectations of low oil prices and the discovery of relatively small fields.

Australian seafloor minerals exploration is a relatively new area of endeavour, with activity concentrating principally in offshore regions of northern Australia. Minerals of interest range from diamonds, to manganese, to sulphides. Pre-competitive geoscientific information is as important to the future of this industry as it is to the petroleum industry.

Scientific information is needed to support policies to guide the safe and environmentally sound management of petroleum exploration and extraction.

Some priorities for address include:

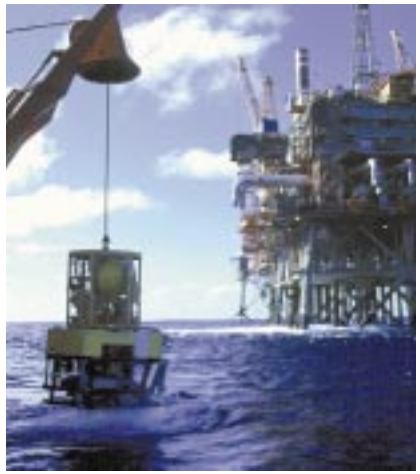
- the identification of all sedimentary basins within the AMJ, and assessment of their prospectivity for petroleum; and
- the development of new technologies to access and develop deep water petroleum resources.

Sustainable Fisheries

Australia's marine fishing industries comprise wild harvest commercial operations, aquaculture, traditional and recreational fishing. Total commercial fish production in 1997/98 (excluding charter and recreational fishing) was conservatively valued at $1.86 billion, of which $1.5 billion was for export.

Many Australian fisheries are based on high value-low volume species. The commercial harvest is generally characterised as stable, but with very few opportunities for growth through production increase. There are some exceptions to this, for example tropical tunas, that are developing rapidly.

Nevertheless, opportunities exist to increase the value of our fisheries by improving technologies for catching,



handling, and post-harvest processing, packing, storage and transport methods, for both live and chilled product – particularly for export markets.

Value adding opportunities include aquaculture. The value and product quality of our Southern bluefin tuna catch has been augmented strongly in recent years through aquaculture of juveniles.

Increasingly, research is being directed to assessing the environmental impacts of fishing. Understanding these

The cost of ignorance

"As the oil and gas industry moves into unknown deeper waters, the cost of exploring the marine environment is outweighed greatly by the cost of ignorance.

This point is best illustrated by an episode on the North West Shelf, where the lack of a basic understanding of the behaviour of internal waves, storm surges and seafloor sediment stability cost one petroleum company more than $80 million.

Sediment scour left the company's ocean floor pipeline suspended without support, an incident that could have been avoided if adequate scientific and oceanographic information had been sought earlier. If this extensive baseline data gathering is done now, industry can develop the ocean's resources with greater security, maximum cost efficiency, and minimal environmental risk."

Ocean Outlook Congress Report (1994)

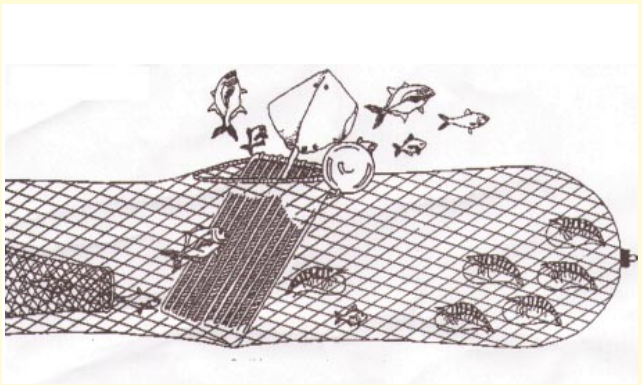
The Northern Prawn Fishery

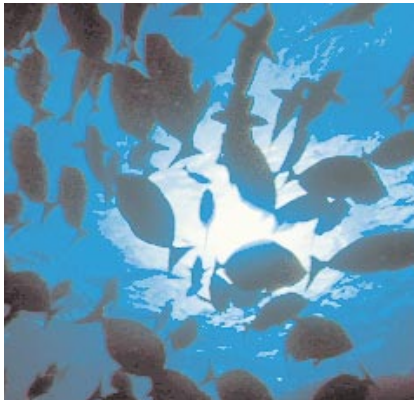
In recent years, fishing effort controls and bycatch issues have shaped the management of Australia's $114m Northern Prawn Fishery. With the support of the Fisheries Research and Development Corporation and the Australian Fisheries Management Authority, CSIRO has conducted research aimed at addressing these two very difficult management issues.

The Northern Prawn Fishery went through a costly restructure between 1987 and 1993, to reduce fleet over-capitalisation and to remediate excessive fishing mortality on tiger prawn stocks. During this period the number of fishing vessels decreased by 60%, but fisheries managers agreed that further effort controls would be required in the future. In 1997 the Northern Prawn Fishery Management Advisory Committee (NORMAC) agreed to consider a new system of effort control in the Fishery, based on net size. NORMAC is already implementing a package of effort reduction measures, including extended seasonal closures, to reduce fishing mortality by 15% by 1999.

CSIRO collected information on technological advances in the Northern Prawn Fishery that had lead to increases in fishing capacity. This data was used to estimate changes in fishing mortality during and after the recent fleet restructure. Over the last 3 years, CSIRO has collected the most comprehensive and fine-scale data-set on fishing effort and catch ever assembled for any trawl fishery in Australia. The data-set is being used to improve the current population models and deliver stock assessments for individual regions of the Fishery.

CSIRO has played a major role in the development, testing and introduction of turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) in prawning trawl nets since 1993. Sophisticated statistical sampling and knowledge of fish behaviour was used to optimise the design of the devices. This research was an important step in preparing the Northern Prawn Fishery fleet for using TEDs and BRDs. In 1998 NORMAC agreed to introduce compulsory use of TEDs and BRDs by the year 2000, and developed one of the first comprehensive bycatch action-plans for any Australian Commonwealth fishery. CSIRO is still carrying out research on bycatch and is presently identifying and describing sustainability indicators for Northern Prawn Fishery bycatch species.





impacts will contribute to developing and refining management strategies and new fishing technologies. For example, over the past five years considerable effort has been put into understanding the fate and effect of bycatch, and in developing gear such as bycatch reduction and turtle excluder devices.

To conserve stocks and their ecosystems, more research is needed into distribution; abundance; population dynamics; stock productivity; species' critical habitats; ecosystem processes that sustain fisheries; stock enhancement techniques; introduced marine pests; impacts of fishing on the environment; improved stock assessment methods; and ecosystem approaches to fisheries management.

To support industry and fisheries managers and to assist resource sustainability, continuing research is needed into wild fish resources and fish habitats, environmental effects of fishing, improved resource access and sharing mechanisms. If fisheries management decisions are to be accepted widely, it will be important to evaluate the economic and social impacts of alternative management regimes.

Aquaculture

Growing world population, particularly in countries with high seafood per capita consumption, will result in a growing gap between demand and supply for seafood in the next century. With Australia's wild fisheries catch volume levelling off, aquaculture offers the only viable means of meeting this growing demand for seafood. Australian commercial aquaculture is small by world standards, but its importance in Australia's fisheries sector has risen strongly in recent years. Aquaculture's contribution to the total value of Australian fisheries production

has increased steadily in recent years to around 30% and the industry's value continues to grow by more than 14% p.a. In 1997/98, aquaculture production was valued at $491 million.

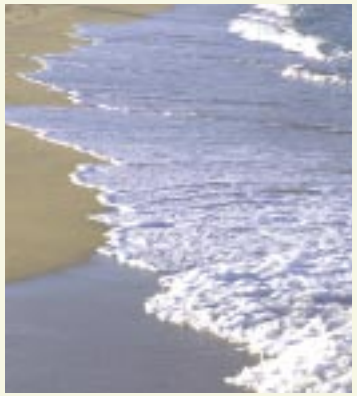
To continue to realise these significant economic returns, aquaculture needs ongoing improvement in farming technology and practices.

The current research effort is directed towards environmental issues, health and disease management, reducing costs of production and increasing production efficiency.

Research priorities vary depending on the species involved. For new species, the priorities may involve closing the life cycle (by breeding from domesticated stock), and developing commercial production technologies. Some

"While marine industries are often economically independent, they draw on a common scientific base and have complex effects on each other. So, for scientific, conservation and exploitation purposes, it is crucial that our marine sector be planned and managed as a complex unity. We are lucky to enjoy such rich marine resources. But it will be by good management alone that Australia will have oceans of wealth in the future."

Review Committee on Marine Industries, Science & Technology, *Oceans of Wealth?* (1989)



high priority research areas include selective breeding, genetic research, the development of improved and more cost effective feeds for larvae and stock grow-out, understanding the pests and diseases of cultured species, reducing the environmental effects of aquaculture facilities, improving site selection and management, and understanding the impacts on aquaculture of land-use and development.

Shipbuilding Technology

Australia's commercial ship building industry occupies a small, export-oriented niche in the production of high-speed aluminium ferries and luxury yachts and naval vessels. Its success depends on continuing progress in developing innovative designs, and advanced manufacturing technologies, maintaining high standards of quality and cost competitiveness, and investigating and targeting new niches and applications.

Defence shipbuilding is a major industry. The Australian Navy's submarines, frigates, minehunters and hydrographic vessels have been, or are being, built in Australia. This building program has involved significant technology transfer to Australia from overseas, and the development and incorporation of innovative elements of Australian technology.

The potential for growth of Australia's defence shipbuilding largely depends on the ability to use its innovative capacity and skills to win export contracts and to diversify. 'Niche' roles are seen for research and design in areas such as developing hull shapes and instrumentation suitable to operating in warm, shallow waters. Strengths will be required in the design and use of new instrumentation technology and materials, computer simulation of vessel performance, and navigational and surveillance technologies.

New hydrodynamics facilities would significantly improve domestic capability in advanced high-speed vessel design, as well as offshore platform design.

Shipping, Safety and Environmental Protection

Australia relies heavily on shipping for the interstate transport of goods, as well as internationally, ranking as the fifth largest user of shipping in the world. Safety in shipping and transport

is most important to safeguard lives, property and the marine environment. Major issues facing the shipping and transport industry relate to environmental concerns, such as minimising or eliminating marine pest introductions through appropriate ballast water management, ports management, the prevention of oil pollution, and technical advances and greater efficiencies in ship production.

Since Australia is one of the world's largest exporters, it is one of the world's largest importers of ballast water. Approximately 11,000 vessels visit our shores each year, departing from approximately 650 overseas ports, and arriving at fewer than 70 ports in Australia. The vessels carry about 150 million tonnes of ballast water.

Research is needed to support the Government's development of a single national ballast water regime and a marine pest incursion management program, and to develop environmentally friendly anti-fouling technologies that will permit the phase-out of tributyltin.

Because ballast water, anti-foulants and other maritime issues are international problems, Australian research and development should be coordinated with overseas efforts.

Technological developments in global positioning systems, forecasting, automatic identification of shipping and traffic management systems have revolutionised accident prevention and response and navigational efficiency, with benefits for the protection of the marine environment. The continuing development of these technologies will further improve shipping safety.

New and Emerging Industries, Services and Technologies

Emerging marine industries could be significant in the long term. They will need appropriate industry support, and a conducive development and regulatory environment. Successful growth of emerging industries will depend,

Ocean Leveller Fast Ferry Ride Control System

The *Ocean Leveller* Ride Control System was developed by the Australian Maritime Engineering CRC (AME CRC), in conjunction with Austal Ships Ltd. This innovative system reduces the motions of fast ferries operating in waves by up to 50% and has been installed on 19 vessels to date, ranging in length from 37m to 86m.

The benefit to Australia has been export orders for the ferries fitted with *Ocean Leveller* to the value of $350m, and direct import replacement of nearly $20 million.

The Problem

Fast ferries operate on many passenger and vehicle routes around the world. Unfortunately, waves can cause the motions onboard a fast vessel to be very unpleasant - causing discomfort and even seasickness. Large motions also make the working conditions of the crew difficult and can lead to unacceptable levels of wear and tear on the vessel.

The Project

In 1992 Austal Ships Ltd, of Western Australia, approached the AME CRC to assist in developing a ride control system for their high speed aluminium ferries. AME CRC designed, built and tested the computer programs for the system executive, the controller algorithms and the user interface. The electronic circuits take the measured signals from the instrumentation, transmit them to the central computer and then receive the signals back for onward transmission to the hydraulics. The hydraulics were also designed, built and tested by AME CRC. Austal Ships designed the actuator system, including the underwater fins and flaps that create the stabilising force.

A computer simulation was developed as a test bed for different controller algorithms and for extensive testing of the final program. It has also been utilised in the development of controllers for other ride control configurations, for example monohulls.

Full-scale sea trials are conducted on each vessel in a variety of sea conditions. The heave, pitch and roll of the vessel are measured and subsequently analysed to determine the performance of the system.

Motion reductions are usually in the range of 35 – 50%.

Through this project AME CRC and its industry partner Austal Ships have developed a close working relationship that has facilitated the transfer of technology between the organisations.

Austal Ships has used the services of AME CRC for several other projects, including the computer prediction of motions of patrol boats operating in a seaway.

among other factors, on basic and applied research.

A number of industries have sound prospects for future growth including state-of-the-art instrumentation technology; environmentally benign antifouling substances for use in the shipping, aquaculture, and oil and gas industries; and Australian marine biotechnology and chemicals research to screen our unique marine living resources for compounds useful in the production of pharmaceuticals, nutriceuticals and agrochemicals.

Strategies should be considered to support the growth and international competitiveness of these industries, services and technologies.

Renewable Energy

Our demand for energy resources continues to grow. This growth will be met in part by more efficient harvesting and processing of traditional energy sources, but will need supplementation by emerging sources of renewable energy, including ocean energy.

The oceans offer several potential sources of renewable energy. Technologies have been developed for energy extraction from waves, tides, offshore winds and ocean thermal stratification.

A number of sites and forms of ocean energy have been identified in Australia for potential development. These could meet up to 8% of national electricity requirements, but their remoteness imposes higher unit costs. Nevertheless, research on the potential for ocean energy, including the continuing identification of suitable sites around Australia, and the commissioning of demonstration plants, should be undertaken as part of an

Impacts, Economics and Management of Recreational Scuba Diving in Marine Protected Areas

Recreational scuba diving is a young industry that has made a big impact on the leisure marketplace in Australia. Diving is a nature-based industry that makes significant use of marine protected areas, a use that will increase as the industry grows.

The Centre for Coastal Management at Southern Cross University received a Commonwealth Government grant to conduct a baseline study of the impacts, economics and management of recreational scuba diving in marine protected areas. The project sets the agenda for the realisation of a sustainable recreational diving industry in Australia.

Two surveys and diver monitoring at four dive sites were part of the project. The results provided a range of management strategies to assist in minimising environmental impact. A few relatively simple strategies could allow for a continued increase in diving without causing any greater impact on the underwater environment.

Underwater Computers for world markets

The Australian Institute of Marine Science (AIMS) has developed the world's first wearable underwater computing system - called the WetPC®. Comprising a Central Processing Unit (CPU), virtual display, and a 5-button keypad, it was originally designed to be used by researchers to collect and display information whilst underwater. It is now clear however that there is significant potential to market the technology in a wide variety of applications world-wide, including defence (mine counter measures, special forces), commercial diving (offshore oil and gas, construction), maritime archaeology, research, and recreational diving.

Two prototype SeaSlate units (see picture) have been produced for the Royal Australian Navy which enable divers to search large areas of seabed without having to install physical markers. The units take the output from a Global Positioning System and plot the diver's swim path in real time. The diver also has access to a variety of information and can enter data on seabed characteristics and any objects found during the search.

AIMS has protected the core invention of the WetPC - its human-machine interface - through lodgement of patent applications in some 25 countries. The keypad interface (based around the concept of "what you see is what you press") is built into the handle, which enables the WetPC to be controlled with one hand. Control of this invention puts Australian industry in a strong position to dominate this as yet untapped market.

The technologies have been licensed to WetPC Pty Ltd which is now working with other Australian companies to develop a new marine industry focused on the provision of underwater computing technologies to a market which is estimated to be worth approximately $200m annually.

assessment of long term energy needs. A number of Commonwealth programs encourage renewable energy use, and ocean energy utilisation proposals would be eligible for consideration.

Coastal and Marine Tourism and Recreation

Coastal and marine tourism and recreation are substantial and fast-growing industries that depend on the continued enjoyment of well-managed coastal and estuarine environments, and our unique marine resources.

Marine tourism involves the direct interactions of people with environmental resources that in some cases can be fragile. The further development of marine tourism and recreation is linked closely with the maintenance of sites and resources in attractive, sustainable and healthy states, and the development of appropriate onshore and nearshore infrastructure. A full understanding of the coastal and marine environment is critical in addressing issues of pollution, waste disposal, erosion, habitat degradation and loss of water quality. A lack of data and understanding of the causes and rates of degradation and recovery are major

issues confronting the tourism industry.

Underlying this is the need for improved basic information about marine environments, and the development, evaluation and application of planning tools to promote environmentally sustainable development of marine tourism and recreation.

Studies of particular destinations, including Australia's islands and the newer wildlife watching areas, would assist sustainable management planning, as would economic, social and cultural research. Data gained from such studies could be incorporated in Regional Marine Plans.

Collaborating to Apply Traditional Knowledge to Marine Resource Use and Management

Aboriginal and Torres Strait Islander peoples have very strong cultural, economic and religious affiliations with coastal lands and sea country, and have a wealth of knowledge concerning marine resources and the functioning of coastal systems. Much of this knowledge is connected to traditional and local uses of these resources.

European settlement has placed additional and sometimes competing demands on some marine resources, creating a need to bring traditional and western scientific knowledge together in integrated approaches to marine resource planning and management. *Australia's Oceans Policy* recognises the importance of the active participation of indigenous Australians in these processes.

Extensive research has been conducted on indigenous coastal lands and sea country over many years. More recently, research has turned to indigenous peoples' needs to achieve their social, cultural, ecological and economic goals.

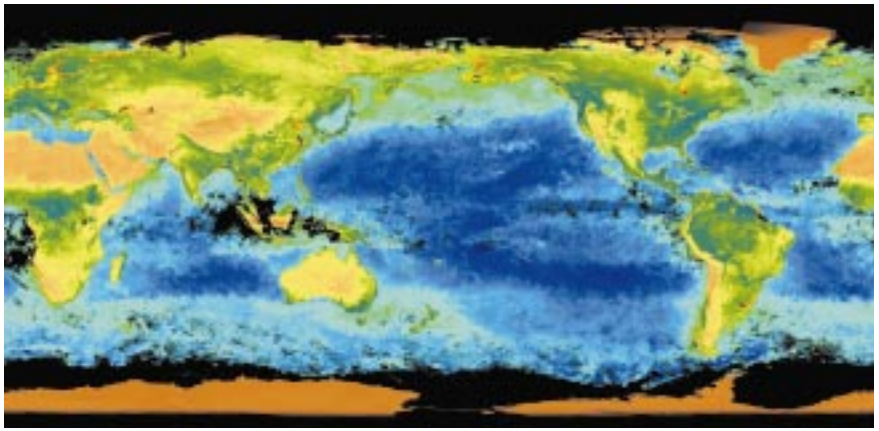
Prominent among these is the development of the capacity to co-manage the resources of their sea country. To develop this capacity, indigenous Australians need the skills and opportunities to be involved in all stages of relevant research, monitoring, surveillance and enforcement.

Security and Navigational Safety in the AMJ

Australian maritime defence and security issues are strongly related to the unique nature of the Australian marine environment. The Australian Defence Force (ADF) must know and understand this marine environment, and be able to use this knowledge to carry out its various functions in a successful and cost-effective manner. Australia's defence and security-related roles have a high reliance on marine science and technology in addressing needs of safety of navigation; protection of shipping in transit; protection of offshore facilities; search and rescue; and surveillance.

Coastwatch, a branch of the Australian Customs Service, is responsible for civil surveillance of Australia's maritime zones and is supported by the ADF's aircraft and patrol boats.

An ongoing priority will be to continue scientific and technological research



into the design and development of maritime defence and surveillance systems.

The more general need to improve marine navigation safety has combined with technology growth to prompt the development of a series of electronic chart systems. In recent years there has also been a marked increase in requests for hydrographic data from marine researchers and other organisations working in the marine environment. Marine navigational safety would be assisted by the development of a digital database of spatially referenced hydrographic information.

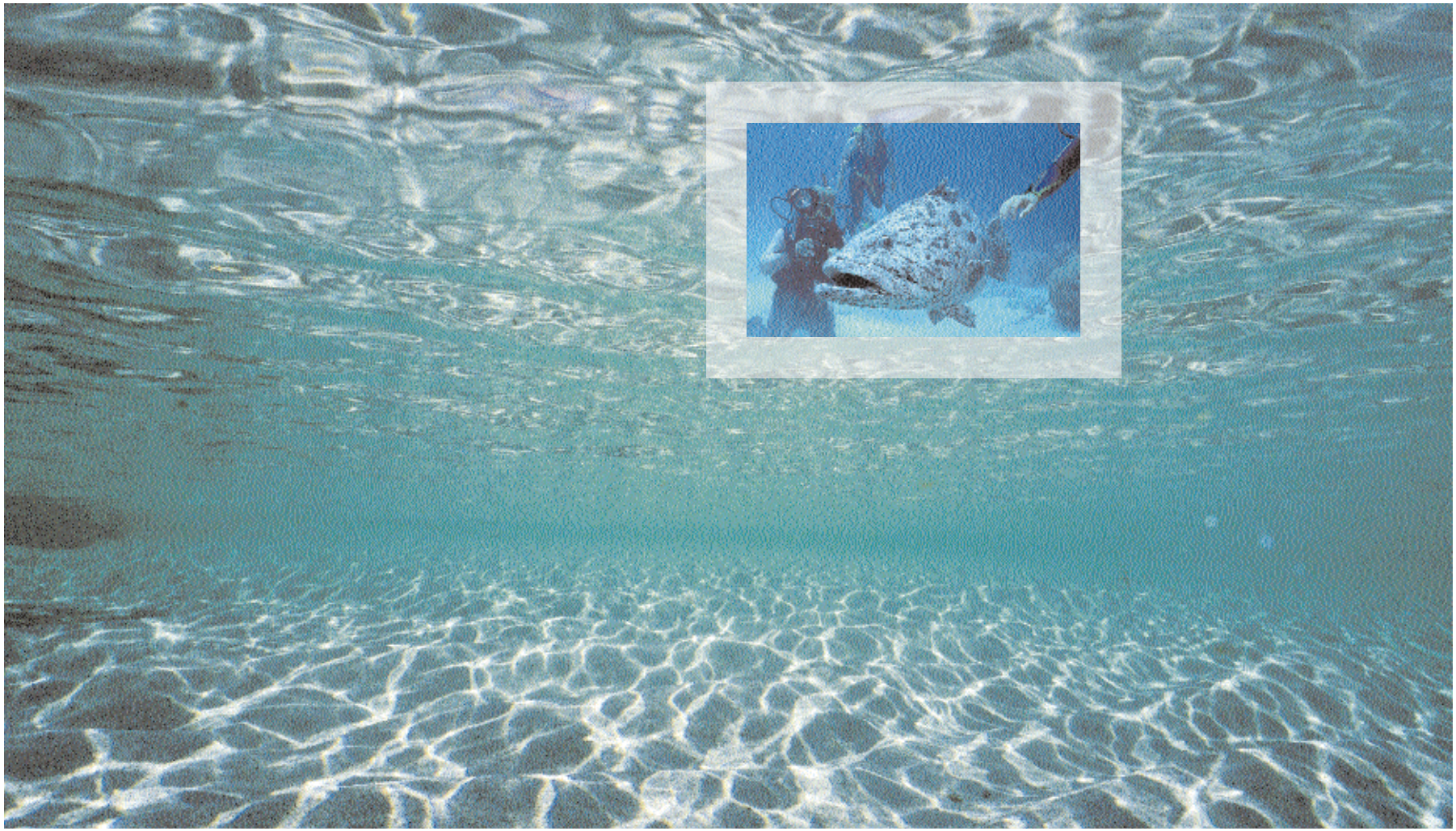
Marine Science and Technology and Marine Law and Policy

Australia must study and manage its marine environment and resources not only because it is in the national interest, but also because it has agreed to discharge a number of marine-related international responsibilities through its links to other nations, international organisations, and treaties. Among these, UNCLOS is particularly important.

Australia is also a party to a number of other conventions and agreements that require scientific information on and understanding of marine systems, for example agreements supporting global and regional meteorological and climate change studies. Additionally, Australia has supported certain declarations to progress the sustainable development and management of its oceans and their resources.

Domestically, many international conventions are reflected in national law. For example, the London Convention is reflected in the *Environment Protection (Sea Dumping) Act 1981*.

The priorities we have are to apply marine science and technology to the protection and preservation of the marine environment; to demonstrate an ongoing commitment to the international conventions to which Australia is a party; and to participate effectively in international programs by gathering and disseminating relevant data.



Program 3: Infrastructure for Understanding and Utilising the Marine Environment

Goal: To provide the physical infrastructure, appropriate skills base and information management support for Australian marine science, technology and engineering.

Objective 1	To ensure the availability of an appropriate skills base in marine science, technology and engineering
Objective 2	To provide the physical infrastructure required for the continuity and improved performance of marine science, technology and engineering in Australia
Objective 3	To implement systematic, coordinated and long-term marine observational programs
Objective 4	To achieve better coordination of marine data management
Objective 5	To build professional expertise and knowledge through increased involvement in regional and global marine science and technology programs
Objective 6	To promote, within the community, the importance of marine science, technology and engineering for sustainable economic growth and quality of life

Program 3

Infrastructure for Understanding and Utilising the Marine Environment

The wide variety of activities contributing to understanding, sustainably using and caring for the marine environment are dependent for their success on the quality of the national skills and infrastructural base. Major physical infrastructure includes special purpose ships, laboratories and buildings, onshore and offshore research stations, and equipment for seabed mapping and sampling. The timely interpretation, integration and effective use of the information and data collected in using these and other facilities requires a strong professional workforce in a multitude of disciplines and marine industries, supported by a vigorous graduate stream.

Skills Base

Australia needs marine researchers, technicians, engineers, and resource managers with expertise in numerous fields, because of the diverse and largely undefined nature of our marine jurisdictions, and the requirement that it be used sustainably. The size of the AMJ also creates demands for people

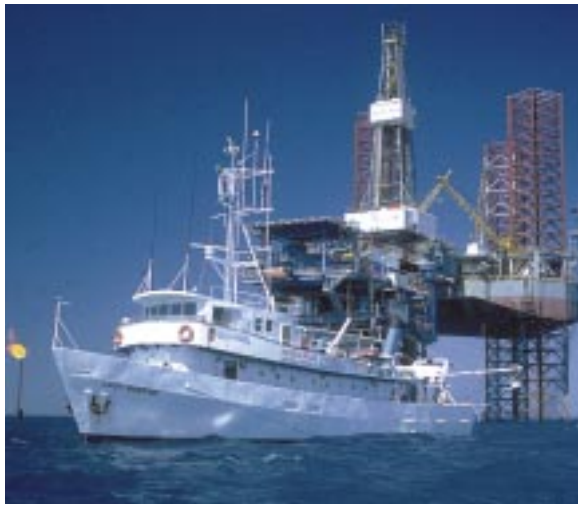
skilled in navigation and surveillance. In attempting to address research issues and problems unique to our AMJ (including those of Antarctica), many of the sciences need improved technologies and instrumentation. There is also a recognised need for training, education and research to produce scientists, engineers and technicians who can rise to the challenge of complex and changing problems, which are often multi-disciplinary.

Both educators and employers have identified the continued and increasing availability of skilled personnel as central to the capacity of marine industries to achieve their potential and to transfer technology into and out of Australia.

We need to identify national needs for skilled scientists, engineers and technicians in the light of Australia's expanded responsibilities and activities in the marine sector, and to train personnel with the knowledge, skills and abilities to meet those needs.

Opportunities for training graduate students in priority research areas need to be expanded by a scheme of scholarships linked to industry and by facilitating their access to marine environments and infrastructure (including vessels).

The inadequacy of the national skills base in taxonomy and systematics has long been a particular concern. These disciplines are critical for describing, and hence understanding, marine species, biological systems, processes and ecology. Improving the taxonomic skills base, especially through schemes designed to foster taxonomic research, should receive high priority.



Infrastructure

Infrastructure needs are closely linked to research programs, both ongoing and proposed. As the need for sustainable resource management grows, so should our capability to implement, monitor and coordinate marine science research programs. The need for a stronger infrastructure base becomes even more evident as we move to emphasise an ecosystem-based and regional multi-disciplinary approach in researching, and better understanding and managing, our marine environment.

Infrastructural means to assist ecosystem and resource management, and to encourage technology-intensive marine industry development, would include:

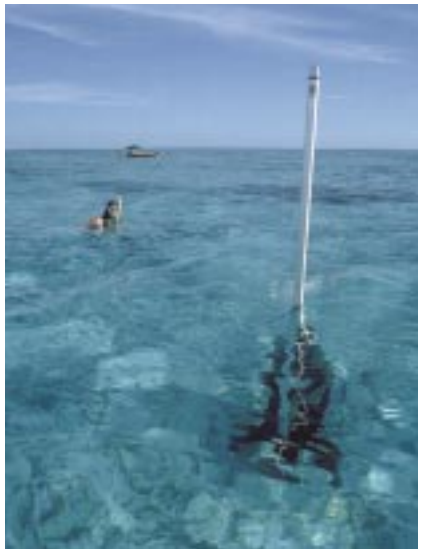
- strengthening and broadening the capabilities of Australia's blue water research fleet;
- new multidisciplinary research facilities in economically important marine regions and adjacent to regions where the research effort is currently inadequate to fully support sustainable industry development, for example in southern temperate waters and in the Timor-Arafura Sea region. The facilities should work with existing university-based, Federal or State research infrastructure, and in collaboration with regional industry, including tourism;
- new hydrodynamic design and testing capabilities;
- refurbished and new coastal and island research stations;
- equipment to fill gaps in under-resourced areas of nationally important and major marine research programs, for example long-term monitoring programs; and
- stronger capability for advanced instrumentation systems design.

Long-term Monitoring Programs

Baseline information on marine biological, physical, geological and chemical characteristics is fundamental for effective marine environment management and the development, support and management of marine industry.

Sound environmental management is dependent upon the comprehensiveness and quality of measured data over long time periods. Baseline data series allow an assessment of the natural variability of ecosystem status over time, and enable anthropogenic impacts from both land- and sea-based activities to be distinguished from this natural variability. Comprehensive and long-term observational data are also critical to predicting climate variability and change and their impacts.

In industry, basic data are necessary to assess the nature, extent, and long-term life or variability in existing and potential resources, to manage the sustainable development of marine industry and to predict potential environmental impacts.



However, our holdings of long term data series are inadequate to meet the present and future needs of industry and standards of responsible environmental management for ecologically sustainable development. The long-term monitoring that is taking place is inadequate to redress the shortcomings and is not nationally systematised.

For effective management, the establishment of a system of long-term monitoring programs and the integration of State and Federal data collection programs is regarded as a matter of priority.

Existing long-term observing programs in Australia may be considered suitable for inclusion in a comprehensive Australian Ocean Observing System (AOOS). This program should involve Federal, State and Territory governments, and would be an effective national response to the challenges set out in the Global Ocean Observing System, established by the Intergovernmental Oceanographic Commission in 1990.

A comprehensive AOOS should identify gaps, and provide support to fill those gaps. The AOOS should develop or adopt novel technologies to provide automated, comprehensive and cost-effective observations of key physical, chemical, geological and biological variables. The AOOS should support the international effort to improve observations in the South Pacific, Indian and Southern Oceans. It is very important for Australia to continue to play a role in the international science

"The capacity for Australia to conduct marine science is intrinsically linked to the infrastructure available for marine scientific work. Marine scientific effort is distributed widely around Australia's coasts and, indeed, needs to be diffuse to be cost effective, efficient and to meet the considerable demands made of it. Despite this, there is a distinct lack of strategically located marine science research facilities around Australia's coasts, and this is particularly true of temperate regions and of tropical regions away from the Great Barrier Reef. It is a fundamental requirement for marine research that there be ready access to field sites and adequate facilities for research activities near those sites. In other words, access alone (with a boat or 4WD vehicle) will not support intensive research programs. Field and research stations are a proven cost-effective means of providing the necessary support and facilitating the type of medium-long term research that realises detailed understanding of marine systems and the processes that drive them."

Australian Marine Sciences Association, *Towards a National Marine Science Policy for Australia* (1997).

community to ensure its continued access to high quality, satellite-derived data. *Australia's Oceans Policy* recognises and supports the importance of establishing AOOS.

Facilities for monitoring pollution and ecosystem health will be needed to accommodate the biological status of Australia's oceans. As they are established, these new observing systems should also become part of AOOS.

The Plan and the Oceans Policy support the Australian, Pacific and Global Oceans Observing Systems as mechanisms to develop the oceans-related data capture and exchange necessary for improving prediction and management, and support:

- research aimed at improving Australia's capabilities in marine meteorological forecasting, climate monitoring and prediction techniques;
- participation in global research and development programs;
- Australian contributions and access to global data sets; and
- participation in international arrangements facilitating data collection, analysis and exchange.

Marine Data Management

The need for a cross-sectoral, nationally coordinated approach to more effectively assemble, store and distribute marine data has been identified by numerous reviews of Australia's marine environment and its management.

Increasingly larger volumes of marine science data are being collected, analysed and stored each year by Commonwealth, State/Territory and local government organisations and the private sector. The effectiveness of data management within these organisations is highly variable, as are the resources available for this task. The volume and complexity of data now being collected, however, dictate that a distributed data management model must be pursued. Individual organisations can no longer expect to keep comprehensive and up-to-date databases, nor maintain the expertise to manage the wide variety of marine data types being captured.

Marine scientific data are a vital underpinning to the understanding and sustainable utilisation of our marine resources and environment.

The Oceans Policy and the Plan recognise that the provision of high quality, accessible and timely marine data is essential for marine planning, biodiversity conservation, meteorological forecasting and marine industry development.

The main priority is to develop a more coordinated approach to marine data management, by establishing a National Marine Data Group (NMDG) serviced by a permanent secretariat within AUSLIG, accountable to an appropriate Ministerial body, and linked to the Heads of (Commonwealth) Marine Agencies and the Commonwealth Spatial Data Committee.

Priority must also be given to strengthening the data management capacity within organisations that deal with marine data.

Regional and International Participation

The Australian marine science, engineering and technology community's is well regarded internationally. This creates opportunities for research and commercial collaborations, and transfer of technologies to other countries. Benefits of international collaboration flow to Australia in a range of ways including personal development opportunities, enhanced capacity of regional neighbours and promotion of Australia's marine capabilities. Participation in regional and global marine science programs provides further national and international benefit.

Priority topics for international science and technology collaboration include fundamental oceanographic and geological research, studies of tropical biodiversity, sea level rise and the prediction of climate variability and change.

Australia's regional interests are focused on Southeast Asia and the Pacific Island countries. The building of collaborations, consultative links and education services are all high priority. We need to improve our capability to provide expert services overseas by continuing to build the size of our base of research expertise.

Marine Science and the Community

80% of Australia's population lives within 50km of the sea. Coastal communities and industry can participate more effectively in managing their local marine and coastal environments if they can access appropriate information and technologies. Marine science, technology and engineering centres and programs provide resources of knowledge and expertise. Projects designed to disseminate this knowledge in schools and communities can generate a greater public awareness of the value and importance of marine environments, and of the role of marine science, technology and engineering in maintaining and improving:

- sustainable ecosystem and species management;
- clean and healthy marine environments; and
- Australian marine industry innovation, efficiency, competitiveness and growth.

A further benefit of such heightened awareness is making young people more aware of marine science and engineering as potential career options.

The Plan and the Oceans Policy strongly support community participation in their implementation, noting that participation is the key to promoting and instituting a duty of care for the marine environment. Participation can be enhanced through dissemination by specialist groups of scientifically-informed materials concerning local marine environments and their management. Moreover, the stake that indigenous peoples hold in coastal waters, the detail of their traditional knowledge and practices, and their capacity to manage collaboratively, needs to be well promoted if the capacity of indigenous management is to be fully utilised and appreciated by the community.

Appendices

MEMBERS OF THE MARINE SCIENCE AND TECHNOLOGY PLAN WORKING GROUP

Dr Ralph Jensen (Chairman)
Former Assistant Secretary, Science & Technology, Department of Industry, Science and Tourism, Canberra, ACT.

Dr Lesley Borowitzka
Manager, Technical Development & Marketing, Betatene Pty Ltd; and Chairman, Glenforrest Stockfeeds Pty Ltd, Perth, WA.

Dr Nan Bray
Chief, CSIRO Division of Marine Research, Hobart, Tasmania.

Professor Peter Davies
Director, Ocean Sciences Institute, Department of Geology and Geophysics, University of Sydney, Sydney, NSW.

Dr Chris Fandry
Project Director, North West Shelf Environmental Management Study, WA Department of Environmental Protection, Perth, WA.

Mr Brian Jeffriess
President, Tuna Boat Owners Association of Australia, and Immediate Past President, Australian Seafood Industry Council, Fullarton, SA.

Professor Craig Johnson
Head, Department of Zoology, University of Tasmania, Hobart, Tasmania, and Immediate Past President, Australian Marine Sciences Association, Hobart, Tasmania.

Professor Tor Hundloe
Director, Technology Management Centre, University of Queensland, Brisbane, Qld, and Chair, Wet Tropics Management Authority, Brisbane, Qld.

Mr Don Lennard
Former Executive Director, Australian Maritime Engineering CRC Ltd, Launceston, Tasmania.

Professor Helene Marsh
Head, School of Tropical Environment Studies and Geography, James Cook University, and Program Leader, Cooperative Research Centre for the Great Barrier Reef World Heritage Area, Townsville, Qld.

Dr Chris Pigram
Chief, Petroleum & Marine Division, Australian Geological Survey Organisation, Canberra, ACT.

Dr Russell Reichelt
Director, Australian Institute of Marine Science, Townsville, Qld, and Chairman, Fisheries Research & Development Corporation.

Department of Industry, Science and Resources Secretariat
Mr Philip Diprose, Ms Deborah Anton, Ms Kylie Naveau, Ms Kirsty Galloway McLean.

ACRONYMS AND ABBREVIATIONS

AAT	Australian Antarctic Territory
AGSO	Australian Geological Survey Organisation
AIMS	Australian Institute of Marine Science
AMJ	Australian Marine Jurisdiction
ANZLIC	Australia New Zealand Land Information Council
AOOS	Australian Ocean Observing System
AUSLIG	Australian Surveying and Land Information Group
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DSTO	Defence Science and Technology Organisation
EEZ	Exclusive Economic Zone
ESD	Ecologically Sustainable Development
ENSO	El Niño Southern Oscillation
FRDC	Fisheries R&D Corporation
GBRMPA	Great Barrier Reef Marine Park Authority
GDP	Gross Domestic Product
GOOS	Global Ocean Observing System
IOC	International Oceanographic Commission
ISR	Department of Industry, Science and Resources
LCS	Legal Continental Shelf
NMDG	National Marine Data Group
PMSEC	Prime Minister's Science and Engineering Council
R&D	Research and Development
SoE	State of the Environment
SOMER	State of the Marine Environment Report
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea

GLOSSARY OF TERMS

Aquaculture Cultivation of fish, molluscs and other aquatic organisms in fresh or salt water for human use.

Benthic Sedentary marine life that lives on the seafloor, and in its sediments.

Biodiversity The variety of all life forms: the different plants, animals and microorganisms, the genes they contain and the ecosystems they form. It is a concept that emphasises the inter-relatedness of the biological world. It is often considered at three levels - genetic diversity, species diversity and ecosystem diversity.

Biogeographic Relating to large regions with distinct landscapes/seascapes, flora and fauna.

Bioregion A region that contains an aggregate of natural communities of organisms whose existence is supported, and constrained, by the region's unique geophysical and climatic attributes. Bioregions may range in scale from thousands of kilometres (e.g. Great Barrier Reef) down to a few kilometres or less (e.g. Port Davey off south-western Tasmania).

Bioregionalisation The process of determining the characteristics and boundaries of bioregions.

Biota The total plant and animal life of a region.

Bycatch Species taken incidentally in a fishery where other species are the target. By-catch species may be of lesser value than the target species and are often discarded.

Coastal Waters All waters landward of the 3 nautical mile limit, but excluding internal waters that are within the constitutional limits of a State.

Cumulative Impact An accumulation of successive or coincident influences or effects on environmental attributes.

Ecologically Sustainable Development Development which meets the needs of the present without compromising the ability of future generations to meet their needs. Development which is compatible with the continuing functioning of essential ecological processes.

Ecosystem A dynamic complex of plant, animal and microorganism communities and their non-living environment interacting as a functional unit.

Ecosystem Integrity The state of the ecosystem being whole and unimpaired, which should be determined by reference to appropriate ecosystem indicators and criteria. Ecosystem integrity is regarded as being maintained when those indicators remain within limits that are agreed as likely to avoid a significant risk of progressive or irreversible change or decline.

El Niño Southern Oscillation Climatic conditions caused by unusual eastward currents in the equatorial Pacific Ocean, characterised by higher sea surface temperatures in the Indian and eastern Pacific Oceans, bringing drought to Australia and seasonal climatic anomalies to many countries around the world.

Endemic A species that is "native" (not introduced) and found only in a given region.

Endemism A measure of the degree of strictly local species in an ecosystem.

Habitat A geographic area that can provide for the key activities of life - the place or type of site in which an organism naturally occurs.

Impact Influence or effect exerted by pressures (usually human activities) on environmental attributes, commonly ecosystems, habitats, communities, species or populations.

Indicators Physical, chemical, biological or socio-economic measures that can be used to assess natural resources and environmental quality that are fundamental to the SoE Reporting process.

Interannual Variations between years.

Introduced Marine Organism Any marine organism that is not indigenous to Australia that becomes established and has been translocated to Australian coastal waters from overseas via shipping or other human activities, such as aquaculture or fisheries and tourism.

Jurisdiction The area and matters over which a Government exercises right, power, or authority.

Marine Protected Area An area of sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.

Monitoring Routine counting, testing or measuring environmental factors or biota to determine their status or condition and to assess changes over time.

Multiple Use Management An approach that aims to achieve integration of user needs in an acceptable balance of outcomes for users and the ecosystem or region.

Nutriceuticals Food products designed to fulfil specific nutritional and dietary needs.

Offshore The comparatively flat zone of variable width extending from the outer margin of the shore to the edge of the continental shelf.

Pelagic Living in the sea or ocean at middle or surface levels.

State of Environment Reporting A tool for providing information on the pressures influencing environmental attributes, the state or conditions of these and the responses initiated to counter identified pressures.

Species A group of plants, animals or microorganisms that have a high degree of similarity and generally can interbreed only among themselves.

Taxonomy The analysis of an organism's characteristics for the purpose of classification.

SELECTED REFERENCES

Australian Marine Sciences Association [Johnson, C (ed)] 1997, *Towards a National Marine Science Policy for Australia*. University of Queensland, Brisbane.

Commonwealth of Australia 1995, *Australia's Ocean Age: Science and Technology for Managing our Ocean Territory.* Report by an independent Working Group to the Prime Minister's Science and Engineering Council at its thirteenth meeting, 8 December 1995. Office of the Chief Scientist, Department of the Prime Minister and Cabinet, AGPS, Canberra.

Commonwealth of Australia 1995, *Our Sea, Our Future, State of the Marine Environment Report* (SOMER). DEST, Canberra.

Commonwealth of Australia 1996, *Australian Maritime Industries: Priorities in Science and Technology.* Report of the ASTEC Shipping Partnership, Australian Science, Technology and Engineering Council. AGPS, Canberra.

Commonwealth of Australia 1997, *Australia's Antarctic Program Beyond 2000: A Framework for the Future.* A Report to the Parliamentary Secretary for the Antarctic. Australian Antarctic Division, Department of the Environment, Kingston.

Commonwealth of Australia 1997, *Marine Industry Development Strategy*. Australian Marine Industries and Sciences Council, Department of Industry, Science and Tourism, Canberra.

Commonwealth of Australia 1997, *Priority Matters*: A Report to the Minister for Science and Technology on Arrangements for Commonwealth Science and Technology by the Chief Scientist, Professor John Stocker. Department of Industry, Science and Tourism, Canberra.

Commonwealth of Australia 1998, *Australia's Oceans Policy, Volumes 1 and 2*. Environment Australia, Canberra.

Department of Foreign Affairs and Trade 1994, *United Nations Convention on the Law of the Sea*. Australian Treaty Series 1994 No.31. AGPS, Canberra.

Fisheries Research & Development Corporation (FRDC) and Australian Institute of Marine Science 1999, *Research Priorities for Fisheries Ecosystems Protection.* Environment Australia, Canberra.

IMCRA Technical Group, ANZECC 1998, *Interim Marine and Coastal Regionalisation for Australia: an ecosystem-based classification for marine and coastal environments.* Environment Australia, Canberra.

Johnson, C. and Neil, D. (eds) 1996, *Managing Australia's Marine Environment: the Way Ahead.* Recommendations of the Marine Environment Conference, Brisbane, February 1995. University of Queensland, Brisbane.

McKinnon, K.R. et al 1989, *Oceans of Wealth?* A Report by the Review Committee on Marine Industries, Science and Technology. AGPS, Canberra.

McKinnon, K.R. 1993, *Review of Marine Research Organisation*. AGPS, Canberra.

Ocean Outlook Congress Steering Committee 1994, *A Report from the Congress*.

Resource Assessment Commission 1993, *Coastal Zone Inquiry: Final Report*. AGPS, Canberra.

Searle, B. 1997, *National Marine Data Policy: A Discussion Paper.* Australian Oceanographic Data Centre, Sydney.

Standing Committee on Fisheries and Aquaculture (SCFA) 1998, *Research Priorities for Australian Fisheries and Aquaculture*.

Photo credits

Front cover: Background – sunset, south east coast NSW, *Tony Karacasonyi*
Inset – The Research Vessel *Lady Basten*, *Australian Institute of Marine Science (AIMS)*
A diver investigates the rich biodiversity of the Great Barrier Reef, (GBR) *Environment Australia*
Seahorse, *National Aquarium and Wildlife Park, Canberra*

Back cover: Seals on Montague Island, *Environment Australia*

Page 1: Natural sunblocking agents in reef coral organisms inspire research into the development of novel commercial and biomedical applications, *AIMS*
Crested terns, *Environment Australia*
Divers investigate a wreck site, *Environment Australia*
Racing yacht, *Australian Maritime Engineering CRC*

Page 4: *S W Herald photo: M. Hallam, Environment Australia*

Page 5: *Photo: M. Cuthill, Great Barrier Reef Marine Park Authority (GBRMPA)*

Page 6: Negotiating the passage to Mermaid Reef, Rowley Shoals, Western Australia, *AIMS*

Page 7: SCUBA divers deploy an Acoustic Doppler Current Profiler off Wheeler Reef, GBR, *AIMS*

Page 8: Narooma Breakwater, New South Wales, *Environment Australia*

Page 10: One Tree Island Research Station, *L. Zell, GBRMPA*

Page 11: A typical winter sea surface temperature pattern for the southern Great Barrier Reef: satellite imagery shows the warm waters of the East Australia Current offshore and cooler coastal waters inshore, *AIMS*

Page 12: Detail, coral reef herbivores – parrotfish and rabbitfish, *Tony Karacasonyi*

Page 13: SCUBA diver with survey equipment, *Environment Australia*

Page 14: Southern Right Whale, *Australian Antarctic Division photo by Clive McMahon © Commonwealth of Australia*

Page 15: Divers investigating coral reef lagoon ecosystems, *AIMS*

Page 17: Seafloor terrain of the continental slope off southern Tasmania, imaged in detail by multibeam sonar (swath mapping) equipment. The image shows submarine volcanoes, typically 300-500 m high: their summit areas are important fishing grounds for orange roughy, *Australian Geological Survey Organisation (AGSO)*

Page 18: Emperor Penguin, *Australian Antarctic Division photo by Dale Opulski © Commonwealth of Australia*

Page 19: Hatchling green turtle, *B. Legg, GBRMPA*
Dugong mother and calf, *Geoff Taylor (Lochman Transparencies)*

Page 20: Research vessel photo, *F. Lovell, Australian Museum*
Researcher, *Environment Australia*

Page 22: Fish, *F. Lovell, Australian Museum*

Page 23: ANARE helicopter, *Australian Antarctic Division photo by Diana Calder © Commonwealth of Australia*

Page 24: A diver investigates the rich biodiversity of the GBR, *Environment Australia*

Page 25: Satellite data shows turbid waters extending across the Torres Strait from New Guinea to the tip of Cape York, *AIMS*

Page 26: Darwin Harbour, *Environment Australia*
Lighthouse, *Environment Australia*

Page 27: Satellite image of Heywood Shoals area: black patches and spots indicate oil seepage at the surface of the sea, *AGSO*

Page 28: Woodside Offshore Petroleum's 'Triton' Remotely Operated Vehicle being launched at the North Rankin 'A' gas production platform on the North West Shelf, *Centre for Marine Science and Technology, Curtin University*

Page 29: The Nordmore Grid, a bycatch reduction device, *CSIRO Marine Research*

Page 30: Fish, *F. Lovell, Australian Museum*
Atlantic salmon aquaculture and its fruits, Port Esperance, southeast Tasmania, *Tassal Ltd*
Beach image, *AIMS*

Page 31: Shipwreck on Samaurez Reef, off the southern GBR, *AIMS*

Page 32: High speed catamaran, *Australian Maritime Engineering CRC*

Page 33: Specialised equipment is used to measure respiration rates of coral and other species in situ, *AIMS*
Coral reefs – a valuable resource for tourism, *AIMS*

Page 34: SCUBA divers with WetPC®, *AIMS and WetPC Pty Ltd*

Page 35: Jet ski race, Sydney Harbour, *Environment Australia*
Detail of 'Burraltja', Djambawa Marawili, Baniyala, NT courtesy of Buku Larrnggay Mulka, Yirrkala, NT

Page 36: Navy surveillance aircraft, *Environment Australia*
Sea-viewing Wide Field-of-view Sensor (SeaWiFS) ocean colour image showing high chlorophyll concentrations in the temperate and polar regions and relatively low concentrations in tropical waters, *AIMS*

Page 37: Shallow inshore waters, *Tony Karacasonyi*
Inset – potato cod and divers, *Andrew Green*

Page 38: Seals on Montague Island, *Environment Australia*

Page 39: Harbour, *Andrew Green*

Page 40: Wave rider buoy off Wheeler Reef, GBR, *AIMS*
The Research Vessel *Lady Basten*, *AIMS*

Page 41: Research investigating the energy of waves on coral reefs. This information allows the development of safe engineering guidelines for construction in tropical shelf waters, *AIMS*

Page 42: One Tree Island Research Station, *L. Zell, GBRMPA*

Page 43: Underwater laser measuring equipment being used to determine growth rates of coral species, *AIMS*

Page 45: Seahorse, *National Aquarium and Wildlife Park, Canberra*

Page 46: *Acropora* coral, Western Australia, *AIMS*

Page 47: A diver investigates reef fish biodiversity by sampling and census, GBR, *AIMS*
Seal on Kangaroo Island, *Environment Australia*