Australia's Marine Environment and Marine Science – Snapshot 2004

Dr Gina M Newton: Vice President, Australian Marine Sciences Association (AMSA)

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Our Land is Girt by Sea!

Australia is the only continental land mass comprising a single nation state. Consequently, the oceans and seas surrounding Australia (and its islands and territories) provide the essential highway that sustains our trade and our economic well being[1]. Australia's marine realm is vast - larger than the continent itself, our Exclusive Economic Zone (EEZ) covers 11 million square kilometres. Beyond the EEZ our extended (claimable) continental shelf off the mainland and the Australian Antarctic Territory extends for a further 5.1 million square kilometres. A submission to the *United Nations Commission on the Limits of the Continental Shelf* to claim Australia's extended continental shelf is planned for late 2004. If successful, at 16.1 million square kilometres, Australia will have one of the largest marine jurisdictions in the world (Fig. 1) and some 70% of our sovereign territory will be marine.

A large marine jurisdiction naturally brings with it 'large' obligations and opportunities through the *United Nations Convention on the Law of the Sea 1982* (UNCLOS). Under UNCLOS Australia has sovereign rights to explore and exploit, conserve and manage, the living and non-living natural resources within its EEZ. It also has jurisdiction over, and responsibility for, offshore installations, marine scientific research and the protection and preservation of the marine environment. Australia will also have sovereign rights to resources such as oil, gas and minerals, of the seabed and subsoil as well as living organisms of its extended continental shelf. [Note: the outer limit of the extended (claimable) continental shelf is based on geological considerations of the natural prolongation of the continent but can never extend beyond 350 nm or 100 m beyond the 2500 m water depth contour[2]]. In addition to the exercise of sovereignty over this vast area, Australia has an international commitment to provide Search and Rescue services over one-tenth of the world's oceans[1]. The provision of charts for the safe navigation of ships and submarines is another international responsibility which Australia discharges over one-eleventh of the world's oceans and which includes extensive inshore areas important to the safe navigation of ships and submarines[1].

A Unique National Asset

As an island continent, Australia's coastline of over 60,000 km (including nearby islands) borders three great ocean systems: the Pacific Ocean in the east, the Indian Ocean in the west, and the Southern Ocean. Along the north coast, Australia is separated from Indonesia, East Timor and Papua New Guinea by the Timor Sea, Arafura Sea and Torres Strait[3] (Fig.1). Australia's marine jurisdiction (AMJ) encompasses all five of the world's oceanic temperature zones, from tropical (25 – 31° C) in the north to polar (-2 to 5° C) in Antarctica[4]. The main ocean currents affecting the marine environment around the continent are the East Australian Current which brings warm equatorial and Coral Sea water down the east coast, and the Leeuwin Current bringing warm, low salinity water down the west coast. Other major ocean features include the sub-tropical and Antarctic convergences and the periodic influence of the El Nino/Southern Oscillation. The latter has

a great effect on ocean temperature and biological productivity, and on Australia's terrestrial climate and agriculture[4]. However, the productivity of Australia's coastal waters is influenced more by land use and the export of nutrients from catchments draining to the coast; the AMJ largely lacks natural upwelling features that bring nutrients to the upper layers of the oceans.

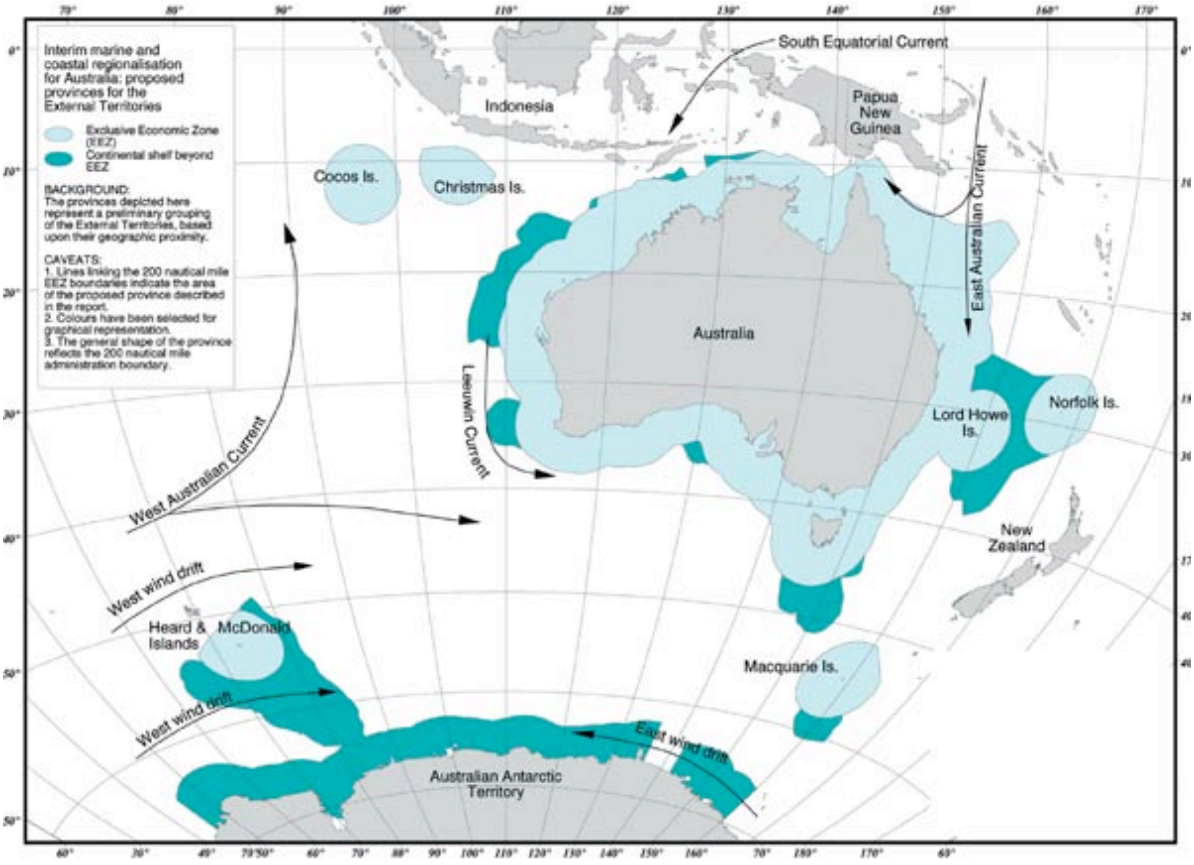

Figure 1: Map of Australian Marine Jurisdiction and major currents[3].

In addition to a full range of temperature zones, there are also a diverse range of habitat types throughout the AMJ, for example:

- Estuaries (over 1000 around Aus.)
- Gulfs and Bays
- Saltmarshes and Saltflats
- Mangroves
- Beaches & Dunes (50% of coastline)
- Intertidal Mudflats
- Seagrass meadows
- Coral Reefs
- Rocky Reefs (support 50% of fisheries)
- Continental Shelf (0 – 200 m)
- Continental Slope & Rise (~200 – 4000 m)
- Seamounts
- Abyssal Plains (~4000 – 6000 m)
- Open Ocean – pelagic (water-column)
- Polar ice/flows
- Antarctic coast

As a result of the great range of temperature zones and habitat types, along with Australia's geographic and evolutionary isolation, our coastal shelf and deep ocean environs boast many globally unique features, for example[3]:

- the world's largest areas and highest species diversity of tropical and temperate seagrasses (30 species)
- the highest mangrove species diversity in the world (43 species)

- one of the largest areas of coral reefs in the world, including the World Heritage listed Great Barrier Reef, and the very different coral reef system off Western Australia (GBR – 360 coral species; Ningaloo Reef 300 coral species)
- a high degree of endemicity (ie. unique to Australia) in our estuarine flora and fauna
- a high degree of endemicity in temperate marine flora and fauna (~80-95%, including 80% of southern temperate inshore fishes)
- the highest levels of biodiversity in the world for a number of groups of marine invertebrates (eg. echinoderms (seastars etc.) , molluscs (snails etc.))

It is sobering to note that while the marine invertebrate phyla represent some 95% of marine biodiversity, the vast majority are yet be discovered and/or identified. At the same time, Australia's taxonomic skills base lacks support and is declining. It is also recognised that biodiversity in the marine environment often peaks on the continental slope, in depths of about 200 to 1000 m. While some 80% of Australia's EEZ is deeper than 200 m, these deepwater systems have been little explored. In fact it is estimated that only 2 to 5% of Australia's entire marine jurisdiction has been explored to date. However, the high biological diversity already known combined with the many different marine ecosystems under the AMJ together represent one of the richest marine biotas on earth, and are therefore extremely valuable national assets[5].

A Valuable, Multiple-Use Resource

Unlike its terrestrial counterpart, Australia's marine environment forms a 'common' national asset, which is used and enjoyed by people who do not possess exclusive rights. This is reflected in the goals of *Australia's Oceans Policy 1998* – "*the benefits from the use of Australia's common ocean resources, and the responsibilities for their continuing health and productivity should be shared by all Australians*"[6]. As a result of its high diversity of habitats and species, the Australian marine jurisdiction represents a complex, multiple-use resource, providing many and varied uses and resources. Australia is highly dependent on its marine resources in a variety of ways, such as:

- preferential human settlement and development in the coastal margin
- recreational use of beaches and near shore area
- the economic and other benefits of marine industries, including shipping, tourism, fisheries, aquaculture, and offshore oil and gas.

The sea is of particular importance to the recreation, culture and spirit of the Australian people, with about 75% of people living within a few kilometres of the coast[3]. Our marine resources have been appreciated by Indigenous cultures for tens of thousands of years and their cultural associations remain strong. Significantly, the trend to move to the coast continues, with all States showing higher population growth rates in the 3 km coastal zone than elsewhere[3]. However, despite these strong cultural ties, relatively few Australians know of the importance to our economy of the shipping and port industries, and of the economic value added to Australia by marine tourism and the seafood industry[3].

Today Australia's marine industries contribute an estimated $50-$60 billion a year to the national economy or at least 8 -10% of GDP (which is more than the agricultural sector)[7,8]. A 1994 study gave the proportional contributions from Australia's major marine-based industries as: 50% for tourism and recreation; 27% for oil, gas and engineering; 13% for shipping, transport and ship building; and 5% for commercial fishing and aquaculture[9]. The

recent (2003) lucrative gas deal with China (which will boost Australia's resource exports by an estimated $25 billion over 25 years[10]), and the steady growth in Australia's aquaculture industry over the past 10 years may change these proportions (although official updated figures are unavailable). Marine industries are also major employers of Australians, particularly in regional areas - for example Australia's defence and commercial shipbuilding industry employs more than 7000 people with about 80% of its output exported[10] and Australia's seafood industry employs over 20,000 in the catching sector alone, with over 80% of product exported[11,12].

In addition to the more traditional marine industries, there are '*hot*' emerging areas which promise future economic and social returns for Australia; some of these include: the use of marine organisms for biotechnology, pharmaceutics and other industrial applications (ie. *biodiscovery*); instrumentation technology; and the use of the marine environment as a renewable energy source. In 1995 an important and visionary report to Government advised that "*Australian marine science and technology will become the backbone to the nation's economic prosperity*"[13]. It seems governments have been slow to catch on!

The Bigger Picture

As well as providing clear tangible benefits, Australia's marine environment also has an important role in the provision of ecosystem services (ie. those functions that sustain or fulfil human life and that cannot be replicated in any other way). Some examples of ecosystem services are: primary and secondary productivity (ie. the food-chain); cycling of nutrients and organic matter; the purification of air and water; and the biological breakdown and recycling of wastes (bioremediation). Preliminary global studies into the relative economic value of ecosystem services have estimated an average value for Australian marine ecosystems of around US$640 billion per year, ie. many times our GDP[3]. Australia's marine and coastal systems also depend on, and influence, global climatic and oceanic current systems. This has implications for the productivity and sustainability of resources and habitats, not just in the sea, but also on the land. At a global level, the tracking of oceanic conditions such as sea-surface temperature and sea level have enormous implications for the prediction of continental weather patterns, agricultural productivity, and future developments regarding global climate change. As the country with the largest marine jurisdiction in the Southern Hemisphere, Australia carries significant national and international obligations in this respect.

The First Environment Status Report

The first comprehensive report on the state of Australia's marine environment was produced only in the last decade. The State of the Marine Environment Report (SOMER) was released in 1995 and resulted from the efforts of 134 scientists and technical experts, a 14 member Advisory Committee and around 160 external reviewers[4]. A major finding of SOMER was that there are serious gaps in scientific knowledge and understanding, both geographically and by issue. In particular the report highlighted a serious lack of long-term data on water quality, environmental health and human uses – ie. the type of data needed to produce rigorous State of the Environment Reports. One reason for this deficit was stated as our vast coastline coupled with a relatively small scientific population – but a lack of clear national policy on marine science and a lack of emphasis on applied research and long-term monitoring programs were also recognised as serious impediments. On the upside we now have *Australia's Oceans Policy*[6] (AOP) released 1998 and its accompanying Regional Marine Planning (RMP) process (a draft of the first of these, the

South-east RMP, was released in October 2003). However, the extremely valuable *Marine Science and Technology Plan*[5] (1999) produced in tandem with the AOP and intended to provide underpinning support, has still not been translated into policy by Government.

SOMER found Australia's marine environment to be "*generally good but..*" – with the condition of specific areas ranging from '*almost pristine*' in very remote, undeveloped areas, to locally '*poor*' off many highly developed urban, industrialised and intensively farmed areas in the south east and south west of the continent[4]. The top five concerns were reported as[4]:

1. ***Declining Water Quality***
   - sediments and nutrients (elevated from land run-off - leading to eutrophication, algal blooms and smothering)
   - oil pollution (from urban run-off, ship spills and operational discharge)
   - heavy metals (localised 'hot-spots' from mining, industry and anti-fouling paints)
   - organochlorines (from herbicides and pesticides in run-off - toxic to marine life and magnified along the food-chain)
   - beach and ocean litter (a growing problem)

2. ***Loss of Marine and Coastal Habitat***
   - degradation of estuaries and coastal lakes (excess nutrients, sediments, acid soil run-off, coastal development, overfishing)
   - significant declines in temperate seagrass (die-back from excess nutrients and sediments, serious and permanent losses in SA, VIC, NSW, SEQLD)
   - loss of mangrove and saltmarsh habitats (important nursery habitat, affected by reclamation, drainage and development)
   - unsustainable coastal development (population pressure)
   - effects of fishing on seafloor communities
   - introduction of foreign species ('pests')
   - population increases in native species (eg. crown of thorns starfish)

3. ***Unsustainable Use of Marine and Coastal Resources***
   - overharvesting of fish stocks and inappropriate practices
   - coastal developments
   - conflicting resource use

4. ***Lack of Marine Science Policy***
   - little geographically comprehensive and long-term scientific data
   - lack of long-term research and coordinated monitoring
   - lack of standardised data and cost-effective indicators

5. ***Lack of Strategic, Integrated Planning***
   - lack of strategic and integrated planning in the coastal zone and catchment
   - lack of non point-source (diffuse) pollution controls
   - insufficient representation of marine protected areas (MPAs)
   - indigenous issues and involvement
   - limited knowledge of social and cultural values of coast and sea

Status Update

Since SOMER there have been two national State of the Environment (SoE) Reports (the *Environment Protection and Biodiversity Conservation Act, 1999* requires reports to be produced every five years). The first of these, *Australia: State of the Environment 1996*[14], reported on the state of Australia's Estuaries and the Sea, and the second, *Australia: State of the Environment 2001*[15] reported against the theme of Australia's Coasts and Oceans. Importantly, the latter attempted to report against environmental indicators for the first time. It also provided a useful update given the six year gap since SOMER. Some favourable and unfavourable news stories from the 2001 Australian SoE Report were[15]:

Favourable news

- the release of *Australia's Oceans Policy* in 1998 which goes some way to addressing the fragmentation of ocean environmental planning and management
- the trialing of a new national management and emergency response system for introduced species (ie. after the black striped mussel event in Darwin Harbour)
- *Bycatch Action Plans* have been developed and implemented in Commonwealth-managed fisheries (eg. turtle excluder devices (TEDs) in Northern Prawn Fishery)
- greater awareness and attention to urban stormwater management and litter prevention by local and State agencies
- a national system of Marine Protected Areas is underway with 194 protected areas covering 60 million hectares, ie. a further 17.6 million hectares of MPAs established since 1996, including the first deep-sea marine reserve (ie. Tasmanian Seamounts). [Note: In 2003 Victoria declared a world-first by implementing a state-wide MPS system representative of all bio-physical regions].

Unfavourable news

- Australian waters are more susceptible to exotic marine pests than previously thought, with threats to both tropical and temperate habitats (55 species of fish and invertebrates reported in SOMER; in 2001 SoE over 200 pest species reported)
- management of coastal environment, including catchment and estuaries, is still fragmented among many agencies at a local and State level
- further loss of coastal habitat through development and tourism pressure
- pressures on coral reefs continue unabated from downstream effects of land use and other human activity; 3% destroyed from climate-related coral bleaching events)
- large nutrient loads of nitrogen and phosphorus still being discharged from diffuse and point sources
- disturbance of coastal acid sulphate soils continues, particularly in NSW and QLD, causing major fish kills and disease outbreaks, and damage to infrastructure
- our national ability to measure the condition of coastal and marine waters through a system of standard indicators has not [much] improved and knowledge remains limited.

Marine Science Magic

Marine science is seen as a principal driver of maritime enterprises, both civilian and defence, and of marine environmental and natural resource management and conservation. 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[5]. 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[5]. Marine science can also be important for increasing the productivity of terrestrial industries. For example, marine scientists have an essential role in providing the latest data on sea temperatures, rising sea levels, climate change and variation – information vital for agricultural management, as well as for cost-effective decision-making, planning and implementation regarding infrastructure – a major expense and focal point of a large section of Australian industry[8].

Despite Australia's relatively small population of professional marine scientists, their work commands international respect. Much of the work of the Marine Divisions of CSIRO, the Australian Institute of Marine Science (AIMS), and the many Cooperative Research Centres, universities, colleges, museums, and government agencies with marine research interests, is world class, and often world leading. An important feature of marine science is its multidisciplinary nature – it is the breadth and mix of subject areas that makes the field so challenging and interesting; some examples are listed below[16]:

- archaeology
- biochemistry
- botany
- chemical oceanography
- chemistry
- conservation
- computing
- economics
- eco-tourism
- education
- engineering
- environmental consulting
- fisheries
- food technology
- geography
- geoscience
- law
- management
- mariculture
- mathematics/statistics
- microbiology
- ocean technology
- parasitology
- pathology
- pharmacology
- oceanography
- remote sensing
- science communication
- taxonomy
- technology
- zoology

Fundamental and ongoing marine science is needed to:

- monitor marine ecosystems and maintain a strong analytical capability
- understand the biogeochemical cycles in the sea
- understand the interactions between the substrate and biota
- understand the behaviour of human inputs to the system - for example agricultural, sewage and industrial pollutants and their impact in time and space
- develop predictive models and decision-support systems to assist in the management of the marine zone, its biodiversity and its resources[13].

The largest and most broadly representative national professional body of marine scientists in Australia is the Australian Marine Sciences Association (AMSA) which has around 1000 members. AMSA is a national non-profit organisation dedicated to advancing marine science in Australia as well as coordinating discussion and debate of marine issues; it also seeks to increase public awareness of the importance of marine science, and of the great diversity of work undertaken by marine scientists. AMSA performs an important role in commenting on marine science issues and in debate of marine and science related policy at State and national levels. The Association is also represented on the Federation of Australian Science and Technological Societies (FASTS) which is a major contributor to national science policy. Some major and recent contributions by AMSA include:

- the publication *Careers In Marine Science* (now in its fifth edition)
- the publication *Toward a National Marine Science Policy for Australia*[17] (1997) – recommendations for a national marine science policy for Australia

- Extensive submissions and involvement in the development of Scientific Diving policy and standards
- *AMSA Position Statement on Marine Protected Areas* and successful submission to the Victorian government on the establishment of MPAs in that State
- A major submission[7] to the Government's *National Research Priorities* process
- A successful submission to the NSW government on the Grey Nurse Shark
- An extensive submission on the Great Barrier Reef Marine Park Authorities Draft Zoning Plan and the associated Representative Areas Program
- A submission on the Government's draft South-east Regional Marine Plan
- Membership of the National Oceans Office Advisory Group (NOAG)
- Membership of the National Steering Committee on the international project, Census of Marine Life (CoML)

Blue Horizons

It is probably fair to say that we know more about distant galaxies of outerspace than we do about the deep-sea that covers over two-thirds of our planet[18]. Oceans are big, deep, wet, powerful and unpredictable and a marine scientist faces significant and expensive challenges in the observation of the ocean and its life[8]. One of the greatest of these challenges is learning how to 'see' into our ocean territory. Space technology has given us a range of new methods for ocean observation. It is through these technologies, such as profiling floats, high-performance computing, robotics and remote sensing, that some of the significant breakthroughs in marine science will emerge[8].

Management of Australia's marine environment is complex; there is an array of domestic legislation and arrangements, but there are also some 80 international agreements relating to the use of the oceans, and half of them relate to managing the marine environment, including fisheries. The current trend toward ecological sustainability and ecosystem-based management (EBM) for natural resources is encouraging and creates a useful framework for policy development and decision making. Its key attribute is the recognition that the effects of any activity in a region should be assessed in light of the linkages and interdependencies within the whole ecosystem. However EBM remains ill-defined at the operational level of management. While we now have *Australia's Oceans Policy* and the related regional marine planning process, there is still no nationally applicable coastal zone policy. Furthermore, the delivery of effective catchment management across all jurisdictions remains problematic[5]. Effective management and conservation will always depend on good marine science and a sound information base. For example, whilst the implementation of management plans will determine whether ecosystems and threatened species will benefit from the establishment from MPAs, the design of the plans and their monitoring and evaluation depend on sound marine science.

Future directions for marine science in regard to the environmental aspects of Australia's marine jurisdiction have also been influenced recently by some important national policy processes. The first of these was the setting of a series of National Research Priorities that took place in late 2002 and for which AMSA made a significant submission – *A National Oceans Blueprint – understanding our marine domain for future health and wealth*[7]. Four major priorities resulted, three of which have relevance to Australia's marine territory: 'sustainable use of biodiversity', 'safeguarding Australia from invasive diseases and pests' and 'frontier technologies'. In 2003 the CSIRO launched its National Research Flagship Program, of which the *Wealth from Oceans Flagship* is an important component. More recently the Australian Government has undertaken a review of Australia's national

research infrastructure. This process is significant to the future conduct of marine science in Australia due to its dependence on research vessels, field-based research stations, and research institutions (at the time of writing the outcomes are unknown).

And Finally….

As stated by the 2001 SoE Report "*Unfortunately there is not much readily available information on the general state of the coasts and oceans environment, and it is 'nobody's job' to coordinate and deliver such information. An effective solution would require specific resourcing and a mandate, supported by all levels of government – possibly through a Ministerial Council*". Similar sentiments were expressed by AMSA's 1997 Policy Statement[17] which recommended the establishment of a National Marine Science Agency underpinned by a National Marine Science Policy. Its seems the horizon has progressed no closer. AMSA is currently working on developing a strategic futures paper, tentatively titled *Australian Marine Science 2020*, hopefully with the engagement of not only the marine science community, but also of marine industries and other stakeholders. Certainly marine science has benefited in the past from positive relations with the shipping industry regarding the gathering of oceanographic data via 'ships of opportunity', particularly in pre-remote sensing times. I hope this paper represents another step in that ongoing, bridge building process!

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