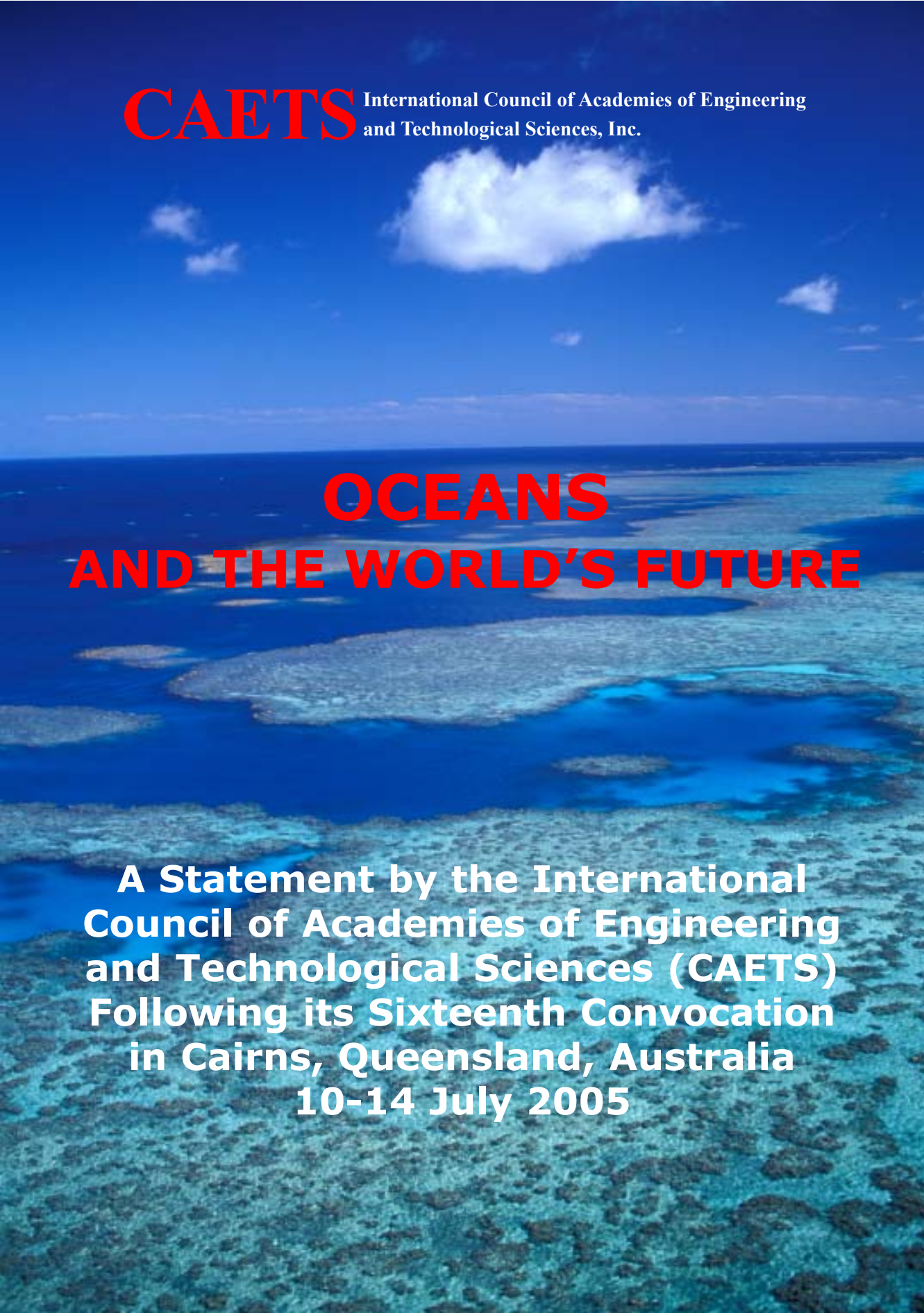

CAETS International Council of Academies of Engineering and Technological Sciences, Inc.

OCEANS AND THE WORLD'S FUTURE

A Statement by the International Council of Academies of Engineering and Technological Sciences (CAETS) Following its Sixteenth Convocation in Cairns, Queensland, Australia 10-14 July 2005

The International Council of Academies of Engineering and Technological Sciences

The International Council of Academies of Engineering and Technological Sciences, Inc. (CAETS) is an independent, non-political, non-governmental international organization of engineering and technological sciences academies, with one member academy per country. Its mission is to foster effective engineering and technological progress for the benefit of societies of all countries.

CAETS was established in 1978 with five founding Academies and held its first Convocation that year in Washington DC at the invitation of the US National Academy of Engineering (NAE). It consists of those national academies who have satisfied an agreed set of membership criteria designed to foster the highest standards of international excellence and who have sought admission and been elected to membership by the Council. Its current membership of 24 academies is listed, with contact details, on the back cover.

The administrative and policy body of CAETS, on which each academy has one representative, is the Council which elects the Officers (President, President-elect, Past President and Secretary/Treasurer) and the Board of Directors which consists of the Officers (the Executive Committee) and four other members each serving, except for the Secretary/Treasurer, for one year terms.

The President, President-elect, Past President and members of the Board of Directors during 2005 were:

- Dr John Zillman, Australian Academy of Technological Sciences and Engineering (ATSE), President
- Prof Achiel van Cauwenberghe, Royal Belgian Academy of Applied Sciences (BACAS), President-elect
- Prof Arne Bjørlykke, Norwegian Academy of Technological Sciences (NTVA), Past President
- Mr William C. Salmon, Secretary/Treasurer
- Prof Ben Veltman, Netherlands Society of Technological Sciences and Engineering (NFTW)
- Lord Alec Broers, Royal Academy of Engineering (RAEng)
- Dr Ki Jun Lee, The National Academy of Engineering of Korea (NAEK)
- Prof Zlatko Kniewald, Croatian Academy of Engineering (HATZ).

Recent Convocations have dealt with the following:

- Creating Wealth in Harmony with the Environment (Eleventh Convocation) Kiruna Sweden, 18-21 June 1995
- Engineering, Innovation and Society (Twelfth Convocation) Edinburgh, United Kingdom, 21-23 May 1997
- Technology and Health (Thirteenth Convocation) Sophia Antipolis, France, 24-27 May 1999
- World Forests and Technology (Fourteenth Convocation) Espo, Finland, 11-15 June 2001
- Entertaining Bytes (Fifteenth Convocation) Hollywood, United States, 18-22 May 2003.

The Sixteenth Convocation was hosted by the Australia Academy of Technological Sciences and Engineering (ATSE) in Cairns, Queensland, Australia on 10-14 July 2005. It was attended by delegations from eighteen CAETS academies and included an international Symposium on 'Oceans and the World's Future' with a total participation in the Symposium and associated events of 200 persons.

On the basis of the keynote address delivered by Dr Patricio Bernal, Executive Secretary of the Intergovernmental Oceanographic Commission (IOC) of UNESCO, invited presentations by 30 speakers and panelists, a closing address by Dr Meryl Williams and a synthesis by Symposium Rapporteurs Dr Greg Tegart, Dr Angus McEwan, Dr Russell Reicheldt and Mr Graeme Kelleher, the CAETS academy delegations reached consensus on the following statement and recomendations which were formally approved by the CAETS Council on 14 July and released on 28 July, 2005. This statement is also included in the Proceedings of the Convocation, copies of which are available from ATSE headquarters at:

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OCEANS AND THE WORLD'S FUTURE

A Statement by the International Council of Academies of Engineering and Technological Sciences (CAETS)

The International Council of Academies of Engineering and Technological Sciences (CAETS) held its 16th Convocation in Cairns, Australia, from 10-14 July 2005, to examine the scientific, technological and engineering issues that link the world's future with the oceans. In the light of the presentations by the international experts assembled for the Convocation and review of the conclusions from the discussions during the Convocation sessions and an associated workshop on tsunamis, CAETS calls for urgent attention to the vital role of the oceans in the world's future. The following Statement, endorsed by the Council on 14 July 2005, sets out CAETS views and recommendations on the application of marine science, technology and engineering in planning for, and working towards, an environmentally, economically and socially sustainable future.

Introduction

Although one third of the global ocean is divided into nationally controlled Exclusive Economic Zones, the ocean is a 'world commons' in which all of humanity has a stake, as set down in the United Nations Convention on the Law of the Sea. Humankind has used and exploited the ocean's resources extensively and sometimes destructively. Through the interconnectedness of the ocean's physical, geological and ecological systems, we all ultimately bear the consequences, good or bad. There is thus an inescapable international responsibility for what happens in and to the ocean.

The tsunami disaster of 26 December 2004 demonstrated the awesome destructive power of the ocean. More gradually, the oceans exert a profound impact on the global biosphere through their influence on weather and climate. At the same time, however, humans are changing the oceans on a comparable scale by, for example, depleting fish stocks and degrading the ecological condition of large parts of the coastal environment.

Science and engineering are the tools by which these interacting systems in the oceans can be understood and, to a significant extent, managed. The Convocation addressed the key issues relevant to the concerted and responsible action of the nations who are custodians of the world's oceans. Its main conclusions and recommendations are summarised below.

Climate change in the ocean is a crucial issue for the future of mankind.

The ocean and the atmosphere are intimately connected. Changes in the pattern of sea surface temperature are linked with changes in the atmospheric circulation. They affect the incidence of extreme weather and are precursors of climatic variability on inter-annual and longer timescales. The enormous thermal inertia of the ocean implies that any systematic change of climate will be of long duration.

With the development of ocean observing systems, the short-term prediction of climate variability is becoming practicable. The link between the El Niño-Southern Oscillation (ENSO) phenomena and inter-annual fluctuations of climate in many regions of the world is fairly well understood. Monitoring networks in the Pacific Ocean now give continuous data on sea surface temperature and subsurface heat content which, when used in numerical ocean-atmosphere models, allow extrapolation forward from the present state for periods of six months or more. Predictions diverge, but ensembles of outputs from different models improve the predictive capacity for a wide range of planning purposes.

The limits of predictability are yet to be tested for longer period fluctuations on the time scales of years to decades. Non linearity in marine and atmospheric systems may limit such predictability. The links between terrestrial climate and patterns of temperature and circulation in the adjacent oceans require more detailed understanding in many regions.

Long-term global warming due to the build up of greenhouse gases in the atmosphere and the increased release of fresh water in the polar regions are believed to have potential for altering the circulation of the entire world ocean, possibly bringing rapid alteration of the global climate patterns. This circulation may be sensitive to changes in particular regions such as the Indian Ocean, with widespread effects in both the ocean and the atmosphere.

The ocean may turn out to be the most reliable forward indicator of global climate change. Changes in the ocean climate are already observable and there is evidence that the human influence is separable from natural long-term variability. In wide regions, the deep ocean is perceptibly warmer and fresher. This warming can also be detected through its contribution to sea-level rise. In contrast, in some areas near the Arctic, there have been changes where the deep ocean is perceptibly cooler and fresher.

Warming can alter the viability of biological regimes, as evidenced by such events as coral bleaching. A rise in carbon dioxide concentration and acidity may seriously prejudice the shell-forming ability of biota, especially corals and modify other flora and fauna species. A drop in pH of 0.1 has been observed in surface waters and it is projected to fall by 0.5 by 2100.

Even modest increases in sea level, when superimposed on natural variability associated with shorter term meteorological influences including storm surges, can severely threaten coastal infrastructure. The water resources of small island communities are especially endangered through salt water contamination of the fresh water 'lenses' lying below the islands.

For all of these, and other, reasons, an improved understanding of the nature and mechanisms of climate change in the oceans is essential to properly informed policy development on all aspects of global climate change.

CAETS recommends continued national and international investment in ocean monitoring and research as a vital input to national and international policy development on climate change and related issues. (Recommendation 1)

Human use of the marine environment must be made sustainable.

Continental shelves and coastal zones comprise about 18% of the Earth's surface. They yield 90% of the fish catch and their margins are inhabited by 60% of the world human population. As spawning grounds, coastal zones and estuaries are vulnerable to land-sourced pollution and the legacy of agricultural and industrial practices. Even with vastly improved scientific data and knowledge, human exploitation and development in many regions, superimposed on natural change, challenges the sustainable future of coastal zones and requires a common understanding and concerted action by governments, industry and the community that transcends sectional interest.

Scientific monitoring and research, enhanced by modern technology and continuous scenario modelling, are essential to provide the tools and knowledge for sensitive and responsible national coastal management policies. As demand on ocean resources increases, the impact of multiple users in a given regional environment spreads to compound the pressure on species and to exacerbate conflicts of interest between the users as well as with those responsible for conservation in the broader public interest. In recent years, methodologies have evolved to reconcile the interests of multiple usage for a sustainable future. In some situations, novel technology such as the creation of artificial reefs can relieve environmental pressure.

Central to these methodologies is the concept of ecosystem management, wherein the effects of the external environment and man-made pressures upon the whole interacting biological system within a region are considered. Such methodologies require an expanded range of technical specialisations such as more sophisticated in-situ observing and quantitative data interpretation technology. Molecular biology will provide new tools for the rapid detection and quantification of environmentally forced change.

Classification of regional-scale habitats in terms of the types of flora and fauna populating them allows dynamic features common to different regions to be compared. The establishment of Marine Protected Areas not only protects zones of particular natural value or sensitivity but assists in separating the effects of naturally occurring change and human intervention.

These mechanisms and technologies must be used as the foundation for ensuring the long-term sustainability of the marine environment.

CAETS recommends national and international endorsement for the commitment of various international organisations to the establishment of a comprehensive global network of Marine Protected Areas by 2012. (Recommendation 2)

Combined social and technological approaches are needed to ensure the future of world fisheries.

Marine fisheries provide about 20% of world animal protein, half of which is diverted to animal or aquaculture feed. Most major wild fisheries are already fully exploited, overfished or exhausted. Technology including new types of ships and nets can increase quality and selectivity. However, national and international regulation of the size and scope of fleets, coupled with enforcement instruments against illegal operations , are essential for future viability of marine fisheries.

Aquaculture at present provides a quarter of fish production and is expected to provide virtually all the increase in supply of marine food in the coming decades. Species used in aquaculture are almost always fed on marine fauna lower in the food chain, placing greater pressure on wild marine ecosystems.

CAETS recommends that effort be urgently applied to develop aquaculture systems that do not depend primarily on fish protein. (Recommendation 3)

New technologies are emerging to enhance the efficiency of marine transport

Eighty percent of international trade is carried by ship and per capita tonnage has quadrupled in the last 50 years. The increased geographic separation of global supply and consumption requires vessels of ever-increasing size and capacity. Increasing global population and prosperity drive a trend to larger special purpose ships and are producing burgeoning growth in cruise shipping. Trends include significant increases in the size and specialization of container and bulk ships, and serious pressures in some high traffic regions. The growth of regional traffic and congestion and the need for access to difficult locations demand adequate ship management and new technical solutions to problems of manoeuvrability, drag reduction, propulsion efficiency and flexibility, ice going capability, marine antifouling and international dispersion of marine species as well as new challenges of terrorism and security.

CAETS recommends an increased effort to ensure that future naval architects integrate engineering, environmental and social knowledge systems to design the ships of tomorrow. (Recommendation 4)

Global petroleum demand is driving ambitious new offshore exploration and extraction technologies.

The increased demand for energy resources will gradually move exploration activity to deeper waters and to environmentally difficult areas like the Arctic. Development of new and improved technology is important for sustainable and environmentally benign exploitation of oil and gas in these areas.

Deeper sites up to 2000 metres are planned to yield 30% of new production and sites to 3500 metres are being considered for the future. Ingenious new methods for remote exploration and extraction are pushing the boundaries of technology, including deviated and multiple drilling, ship and semi-submersible platforms, spars, and total sub-sea processing systems, coiled tube drilling, expandable casings and multilateral extended reach wells. Deep water production is feasible using artificial sub-surface well-heads, sub-sea down-hole processing, separation, re-injection, compression, riser-less light well intervention and multiphase flow simulation including the use of hydrates.

The cost and technical difficulty of developing offshore sites demands more accurate assessment of their prospectivity using numerical synthesis and analysis of vast quantities of seismic and other data. New techniques for exploration include electromagnetic seabed logging, seismic exploration and modelling of reservoirs and super-long seismic arrays.

CAETS recommends continuing encouragement for innovative new technologies for remote exploration and extraction of oil and gas. (Recommendation 5)

The oceans can provide new resources of energy and minerals

The increasingly high cost of energy derived from conventional sources will encourage commercial production of gas from gas hydrates. Some evaluations of future energy resources indicate that gas hydrate may be just as important a source of energy as oil and gas. Gas hydrates occur in the upper part of the sediments or on the seabed in oceans and the study of these deposits is just beginning.

Ocean currents, waves and tidal movements represent a vast amount of energy. If successfully exploited, they could contribute a substantial supply of electricity in coastal areas in many parts of the world.

On the seabed in the deeper ocean, manganese nodules occur over large areas and represent large resources of copper, cobalt and nickel for the future. These resources, together with sulphide deposits along spreading ridges and cobalt crust at some oceanic islands are now part of the resource management of the International Seabed Authority.

Our knowledge about the seabed is less than our knowledge of the surface of Mars, both in the high seas and in the Exclusive Economic Zones. We must increase the mapping of the seabed both in the deep oceans and on the continental shelves. A better geospatial knowledge base is necessary for monitoring and sustainable development of the resources in oceanic regions.

CAETS recommends that more detailed mapping of the seabed be carried out as a basis for discovery and sustainable management of oil, gas, gas hydrate and mineral resources. (Recommendation 6)

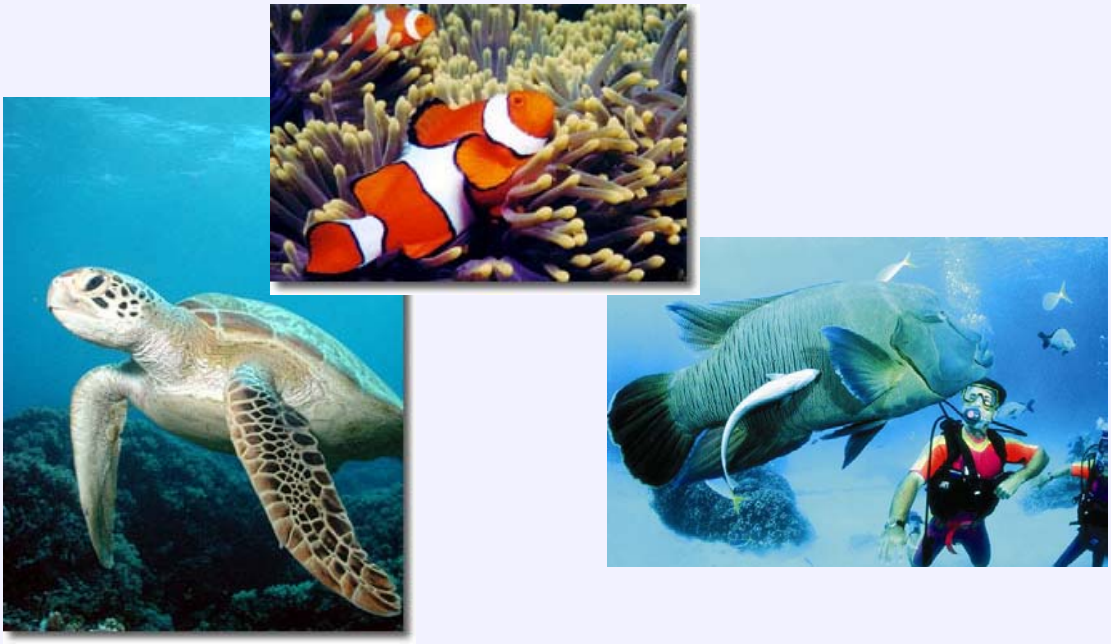
To secure the sustainable future of the oceans and their resources, we must continue to develop new technologies for monitoring and data processing.

In recent decades, there have been revolutionary technological advances in remote sensing, global positioning, miniaturization, automation and digital computation, with the capacity to acquire, assimilate, combine and distribute vast amounts of quantitative data using the Internet. It is now technically feasible to accumulate observations with sufficient coverage and accuracy to explore the ocean depths and below the seabed, to detect changes as they occur and to perform simulations and apply scientific knowledge to provide options for human intervention in the management and use of our ocean resources.

This capability is well advanced in pilot projects to describe the influence of ocean circulation on global and regional climate. We require a far greater national commitment to support the use of this technology in internationally coordinated programmes in the form of global "earth observing systems", of which the Global Ocean Observing System (GOOS), coordinated by the Intergovernmental Oceanographic Commission (IOC) of UNESCO and implemented through national observing programmes, is a key part. The gathering and assimilation of data in large quantities within 'operational' oceanographic systems (akin to, and linked with, meteorological service systems) should result in the routine generation of data products and the application of models and techniques that can be accessed and applied to questions involving the complex interaction between physical and biological processes.

CAETS recommends the free and open international exchange of primary data in order to release the full power of global observations for a wide range of important economic and environmental applications in addition to climate research and prediction (Recommendation 7)

CAETS recommends the establishment of national oceanographic service organizations to facilitate participation in international data exchange and to deliver the benefits of operational oceanographic services to national communities. (Recommendation 8)



We must develop and exploit emerging technologies for disaster reduction.

The South East Asian and Indian Ocean tsunami of 26 December 2004 provided a grim reminder of the vulnerability of human communities to the immense destructive power of the ocean in response to tectonic forces.

This event has provided forceful motivation for renewed international cooperation in the effective use of science and engineering to mitigate the impact of natural disasters and, in particular, to upgrade the systematic monitoring of both seismic and sea level characteristics to ensure rapid warning and community response, for tsunamis and other (more frequent) natural ocean hazards such as hurricanes and storm surges.

Through international cooperation, it is expected that the upgrading will involve improvements in both our physical observing systems and our communications systems. Working through existing international organizations such as the IOC and the World Meteorological Organization (WMO), the newly established Global Earth Observation System of Systems (GEOSS) will provide a framework to promote the development and worldwide implementation of the required observing and communications technologies.

Also required at national level is the development of much more sophisticated natural disaster mitigation plans drawing on available science (including social science) and technology and existing international systems of cooperation.

CAETS recommends international support for the establishment of a global tsunami warning system, with initial priority for the Indian Ocean. (Recommendation 9)

The academies have a key role to play in ensuring the wise and sustainable use of the oceans.

The Convocation concluded that the health and viability of ecological systems in the ocean are widely threatened by human pressures. Furthermore, human-induced greenhouse warming and associated changes in the ocean may bring serious consequences for mankind. However, with international will and cooperation, there is now great potential for nations, individually and collectively, to detect changes as they occur and a greater capacity than ever before to employ the capabilities of science, technology and engineering to ensure wise and prudent use of the oceans for the future of the world.

The academies can help in many ways through studies, information and advice. Capacity building through education and training in the area of ocean science and engineering should be a priority for national governments and multinational institutions like UNESCO, particularly in the third world. Special emphasis on sustainability and environmental implications should be made in such programmes.

CAETS recommends that its Member academies increase their commitment to initiatives for raising public awareness of ocean issues, including scientific and technological solutions to the threats facing the oceans and their implications for society; and that they enhance their input to national governments and international organisations to ensure informed and balanced advice on ocean policy issues. (Recommendation 10)

Recommendations

In the light of its conclusions, as summarised above, CAETS commends, for consideration and action by all appropriate national and international organisations, the following consolidated set of ten recommendations from its 16th Convocation:

1 *CAETS recommends continued national and international investment in ocean monitoring and research as a vital input to national and international policy development on climate change and related issues.*

2 *CAETS recommends national and international endorsement for the commitment of various international organisations to the establishment of a comprehensive global network of Marine Protected Areas by 2012.*

3 *CAETS recommends that effort be urgently applied to develop aquaculture systems that do not depend primarily on fish protein.*

4 *CAETS recommends an increased effort to ensure that future naval architects integrate engineering, environmental and social knowledge systems to design the ships of tomorrow.*

5 *CAETS recommends continuing encouragement for innovative new technologies for remote exploration and extraction of oil and gas.*

6 *CAETS recommends that more detailed mapping of the seabed be carried out as a basis for discovery and sustainable management of oil, gas, gas hydrate and mineral resources.*

7 *CAETS recommends the free and open international exchange of primary data in order to release the full power of global observations for a wide range of important economic and environmental applications in addition to climate research and prediction.*

8 *CAETS recommends the establishment of national oceanographic service organizations to facilitate participation in international data exchange and to deliver the benefits of operational oceanographic services to national communities.*

9 *CAETS recommends international support for the establishment of a global tsunami warning system, with initial priority for the Indian Ocean.*

10 *CAETS recommends that its Member academies increase their commitment to initiatives for raising public awareness of ocean issues, including scientific and technological solutions to the threats facing the oceans and their implications for society; and that they enhance their input to national governments and international organisations to ensure informed and balanced advice on ocean policy issues.*

Members of CAETS Academy Delegations attending the Council Meeting of 14 July 2005

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