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THE OCEAN AND HUMAN FUTURE

The purpose of this document is to provide basic scientific and overview information for the High Level Meeting to be convened by the President of Portugal and Professor Federico Mayor, Director-General of UNESCO, aimed at bringing the importance of the ocean for the environment and development, with related research and systematic ocean observations, for the attention of High Level decision makers.

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EXECUTIVE SUMMARY

1. The oceans have always played and will continue to play a decisive role in shaping the life of this planet. The global energy budget and the biogeochemical processes on which all life depends are critically influenced by the oceans.

2. The near-shore maritime areas contain the largest part of commercially exploitable marine living and mineral resources. They are also the zones used for mariculture, whose full potential is yet to be developed, tourism, recreation, sport, harbour and marine constructions, through waste and sewage disposal; and they receive other contaminants and nutrients through river runoffs.

3. The adoption of the 1982 United Nations Convention of the Law of the Sea has stimulated coastal States to increase their understanding of maritime areas adjacent to their coasts through the application of marine science and technology. The Convention provides a definition of the extent of a coastal state's jurisdiction. It established the Exclusive Economic Zone of up to 200 nautical miles within which the coastal State may exercise sovereign rights with regard to the utilization and management of natural resources, living and non-living, in the water, sea-bed, and subsoil. The Convention makes provision for scientific research within the marine areas under national jurisdiction and the Exclusive Economic Zone of coastal States. In general, the coastal seas are now a "national resource" and the new UN Law of the Sea calls for regional co-operation in formulating and implementing management and conservation strategies.

4. Further advancement in ocean sciences and in a wise utilization of the resources of the ocean requires the application of advanced ocean technology. Developments in technology in the past twenty years have had an enormous influence on ocean research and the way it is planned and undertaken. Scientific instrumentation for continuous and automated measurements of ocean parameters has been developed, and manned and remotely operated sub-marine vehicles permit scientific and commercial operations in the complex environment of the depths of the ocean. Satellites sensing ocean temperatures, waves, sea-surface levels, and ocean colour related to biological productivity, have passed through the stages of development and validation to become operational tools alongside the traditional, but still essential fleet of research vessels. Developments in the computer sciences allow long-term data collection, dissemination, and storage, followed by handling and evaluation on a scale orders-of-magnitude greater than was previously conceivable. Furthermore, computerized communication systems allow scientists around the world to exchange data, information and ideas and thus facilitate truly global scientific co-operation.

5. This progress, if properly used and widely shared, provides for much improved opportunities for a sustainable development and wise use of the marine environment and its resources, including the conservation of critical habitats and species, and their rational utilization based on the basic concept of sustainable yield. This progress must be based on scientific findings, interpreted for common use, and on concerted ocean observation systems that can help provide a data base for reliable predictions of change (physical, chemical, as well as biological).

6. Long-term systematic research and observation programmes should be organized according to a globally co-ordinated strategy to monitor the changes in the state of the marine and coastal environments and of ocean processes, and their interaction with atmospheric and terrestrial processes. The results of the research and observations should be critically evaluated and widely disseminated through easily accessible data bases. For the future, it is important that the gap between developed and developing countries be bridged and further steps taken, as far as possible, to fully re-establish the confidence and partnership between governments and scientists. Steps should be taken to ensure a rational application of the provisions of the consent regime, which would, at the same time, benefit the development of the scientific capability, especially of developing countries and international scientific co-operation. In this respect, some of the major question marks, for example, with regard to the role of the oceans in global climate change, need to be addressed.

7. However, no combination of policies, technologies and resources can significantly improve the present situation, *unless the non-technological roots of the problems are overcome*: population pressure on limited resources and space, competitive nationalism, the globally unbalanced distribution of wealth and opportunity, the notion that economic growth and human well-being are directly

proportional and, last but not least, the illusion that supposes civilizations to be self-supporting without help from natural ecosystems. In order to achieve these, *a new attitude, based on global solidarity,* seems to be required.

8. The increasing world population places an ever-growing pressure on land-based resources. The demand for marine products and ocean services will increase in parallel and increase the need for marine research and services. The living resources of the oceans have been exploited over very long periods of time through traditional fisheries operations, but the new era of cultivating the marine living resources, exploitation of the mineral resources and ocean properties, through the application of modern science and technology, has scarcely begun.

9. The concept of sustainable development will be in focus with the future utilization of marine resources and environment, but there is widespread concern that man's activities may be adversely affecting the earth's environment. The ocean plays a dominant role in maintaining the life-supporting system on earth through its interaction with the atmosphere, although the details of that role have yet to be fully understood. Concern over the environment and its changes is likely to shape the future of marine programmes in research and services.

10. In spite of great technological developments, many challenges remain to be met. The cost, scale, and complexity of global ocean studies demand clear goals, international co-operation, and the co-ordination of common services. However, studies of the ocean and plans for exploitation are often poorly integrated. National policy for marine affairs is usually fragmented among government departments, for example with separate responsibilities for energy, mineral resources, pollution control, fishing, shipping, and defense.

11. The key to progress must be co-operation by governments. They must make the long-term commitment to fund the necessary research and associated interpretation of results for management use, the long-term observing systems, and data evaluation. Global studies are beyond the resources of any single national authority. There must be a willingness on the part of governments and scientists to work together over a long period of time. Co-operation will include shared operation of technical facilities such as ships, satellites and new automated devices, and the facilitation of access to EEZ's for routine ocean monitoring purposes.

12. Observations from satellites will revolutionize marine measurements over the next 20 years. These should be available to all scientists working on global and regional studies. Existing international frameworks for ocean data analysis and exchange have established a system which works, and which is often cited as an example for other environmental services. The existing mechanisms for co-ordination and co-operation, in particular IOC, have played a major role in this development. However, exchange mechanisms are under-funded and in some countries they no longer operate. Valuable data, needed for studies of climate and pollution trends, have already been lost.

13. What kinds of marine research are needed for sustained development? What are the needs of third world countries in this regard? How can industrialized nations, the scientific community, and funding agencies cope with these needs? Where should the money come from and where should it go? Major restructuring of approaches to partnership and co-operation in the fields of marine science and services is needed if the problems facing the world community are to be adequately addressed.

14. Such restructuring is necessitated by the important role of the worlds oceans in climatic change, both as a fundamental component of the systems controlling global weather and climate, and as a result of the fact that major impacts resulting from climatic change may be expected to occur in and around coastal zones, near-shore areas and low-lying land. Predicted impacts of climatic change may result in dramatic changes in ocean resource distribution and productivity, in coastal infrastructure associated with marine transportation systems, and in increased frequency and severity of natural hazards in the coastal zones of the world. Not only are developing countries vulnerable to such changes, but unlike the more industrialized nations of the world, many lack the necessary capabilities in marine science which will enable them to address and plan for the predicted adverse impacts of such changes.

15. The global nature of predicted impacts resulting from climatic change necessitates global approaches to potential solutions, and therefore partnership in marine science takes on a more prominent and important global role than in the past.

16. The solution to global problems must be sought through international and intergovernmental co-operation. Decisions are needed now to enable the world community, by a collective scientific effort at national, regional and global levels, to understand global change of which the ocean is a major element. Through improved knowledge of the ocean and its resources, on local, regional and global scales, Member States can strengthen their capabilities for socio-economic progress while contributing to the well-being and sustainable development of humankind as a whole.

17. The following major directions should meet the challenges and opportunities. Many are now being addressed through on-going programmes, but achieving them fully will require concerted action and additional commitments by Governments and international co-ordination through the end of the century and beyond:

(a) Global climate research programmes and the associated large-scale oceanographic experiments to observe and understand air-sea interaction, the impact of the ocean on climate, and the impact of changing climate on the ocean.

(b) Research and monitoring of marine pollution to measure and assess the effects of human activity, notably those resulting in degradation and contamination, especially in the coastal interface zones.

(c) Study of the marine environment as a whole - both coastal and open-ocean - its physical and biological parameters and processes, with emphasis upon its role as a residence for living resources, its geological and geophysical properties, including non-living resources in shallow and deep-ocean areas, and the interfaces between the ocean, its floor, and the atmosphere.

(d) Accelerated development of ocean observing and monitoring systems leading to an adequate Global Ocean Observing System in support of marine research and ocean use, as a common service to Governments and their marine user communities.

18. The application of environmentally sound management practices in coastal and maritime activities, rather than narrowly defined "conservation", is now accepted as one key to safeguarding and developing the marine and coastal environments and their resources. The unplanned or poorly planned land- and sea-use practices, the irrational exploitation of natural resources, and the pollution to which they incidentally give rise, can be avoided through these means. Management implies rational use. Emphasis on the concept of integrated management reflects a critical change from earlier views of most environmentalists that the oceans had to be preserved unchanged rather than used rationally.

19. The lack of funds, particularly in developing countries, is the crucial and single major impediment to a more forceful development based on sound environmental principles. The remedy, without which all measures and decisions will remain only at the level of declarations, is in the provision of financial resources additional to those currently available, enabling the disadvantaged countries to become equal partners in dealing with global economic developmental and environmental issues. The financial resources required are of an unprecedented magnitude, unlikely to be met from regular government budgets. They could come from increased flow of assistance through the mechanisms of international agreements between developing countries and lending/funding/donor/aid agencies and countries, or from new multilateral funds through which such resources would be channelled to disadvantaged countries.

20. It is also evident that in this world all, including poor and developing countries, need a corps of scientists to select and adapt knowledge, to use and repair foreign and new technology and to provide independent scientific advice to their governments in national as well as international contexts.

I. A WIDE ROLE OF MARINE RESEARCH AND RELATED NEEDS

21. It should be noted that different countries have differing needs and opportunities in the fields of marine science, and that the state of marine science development in a particular country may not reflect its overall stage of development. In some instances, developing countries have well established marine science capabilities. In most cases, spending is very limited and funding for research is largely directed to the investigation of immediate, resource-related problems. Little is invested, either nationally or internationally, in

strengthening the capabilities of such countries in addressing more broadly based research problems. The limited national investment in science education in many countries frequently results in general shortages in skilled scientific and technical manpower in science-related fields which, in turn, results in competition for such scarce resources between marine science and related professions.

22. Where science policies exist in developing countries, they generally place greater emphasis on applied science and less on more basic science. Such an emphasis leads to stagnation and is unproductive in the longer term since it fails to provide a sufficiently broad approach to marine science problems, their potential solution, and the application of science to the problems of sustainable development. It is important, therefore, that cogent arguments are presented to developing country partners in collaborative international programmes, which emphasize the importance of creating a balanced marine science capability. Unfortunately, the scarcity of resources, both financial and manpower, precludes extensive investment by such countries in investigating any, except the most immediate and critical marine environmental management problems. However, without basic science there will be no applied science.

23. Wherever industrialized countries support marine research in developing countries, the prevailing view seems to be that only applied research should receive support. It is important to recognize that in marine science the dividing line between applied science on the one hand, and basic science on the other, is tenuous at best. Indeed, any consideration of marine problems and issues will immediately demonstrate that the two are inextricably linked, and that attempts to separate them are both artificial and counterproductive.

24. The immediate importance of "basic" research and hence the need for support for such endeavours is well illustrated by the El Niño phenomenon where meteorological and oceanographic processes must be understood if predictions are to be made concerning the occurrence of the phenomenon. Appropriate management strategies for utilizing living resources, whose distribution and abundance are dramatically altered during El Niño events, can only be formulated when predictive models are produced and the basic causes of the phenomenon understood. The fundamental relationship between an understanding of basic physical and biological processes in the oceans and the development of sound management plans for the marine environment as a whole, must be recognized by funding agencies, governments and marine scientists alike, if sustainable development in relation to the sea is to become more than an unattainable ideal.

25. In addition to a concern with the problems of resource management, marine science has a vital role to play in other fields. For example, current global circulation models on which projections of future climates depend, are inadequate, due to a lack of adequate data and understanding of the basic processes. The need for an increased data base, particularly in areas of the worlds oceans bordered by developing countries and remote areas, is obvious if the present uncertainties in global models are to be reduced or eliminated. It is imperative that such fundamental areas of uncertainty be addressed during the implementation of future research in marine science.

26. The coastal zone is regarded as an important resource in itself, which provides a venue for often highly concentrated socio-economic activities. The needs of countries in terms of developing integrated coastal zone management plans are growing as the human population increases, and marine science must address the issues of coastal protection, of coastal ecosystem management, of aquaculture and of coastal pollution by providing a sound scientific basis on which such management plans may be formulated. It is abundantly clear that marine science has a vital role to play in achieving sound and sustainable management of the ocean, its coasts and its resources.

27. The role of marine science is, however, wider than this; the prospects of global climatic change set new goals in the various disciplines of marine sciences which may be achievable only if marine scientists, national and international agencies establish satisfactory new forms of partnership and collaboration.

28. An important aspect of future directions in marine science must encompass the integration of open ocean research programmes with those on shelf seas and in the coastal zones. Consideration of open ocean processes in isolation or separately from the processes occurring in coastal zones will be counterproductive in the face of such global threats as climatic changes and sea level rise.

29. The challenge for marine science is therefore not only to address its current role but to redefine its objectives so that new goals and targets can be met expeditiously and economically. The United Nations Convention on the Law of the Sea provides an initial framework within which marine science and marine scientists in different countries may engage in partnership to achieve these new goals. This requires the establishment of linkages and support structures throughout the global, scientific community; the provision of training opportunities and the necessary equipment to establish an indigenous capability in various aspects of marine science; the provision of ocean services such as hazard warning systems, observation and monitoring networks, baseline modelling and data systems with inbuilt data quality assurance and exchange mechanisms; and through such mechanisms contributing to the overall development goals and strategies of poorer nations.

30. Responsibility for the development of a marine science capability rests ultimately with each individual country; nevertheless, countries with a well developed marine science capability have a responsibility to assist in the development of a similar capability in less developed nations. One way in which such capabilities may be established is through collaborative and truly international partnerships in the fields of marine science and provision of services designed to address the common and often divergent needs of all participants. National level capabilities in marine science are a requirement for the effective implementation of national, regional and international programmes in marine science.

31. While the problems of developing a marine science capability reflect different resources, different cultures and different problems in each country, certain fundamental issues in marine science are truly global, and as such require a concerted global approach to their solution. To develop such a global approach requires the establishment of an indigenous capability in marine science such that developing countries may participate as full partners in global programmes rather than functioning merely as data collection points in global networks.

32. In the light of this it is imperative that countries with a well established marine science capability assist in developing a national commitment in less developed countries to continue support for marine science. Several countries where such a commitment was initially made now face economic problems in continuing their support to marine science and such difficulties must be recognized by international agencies in apportioning support to marine science globally.

33. The present situation in some countries, particularly small island states, may preclude the development of a full indigenous capability in marine science, and for these countries it may well be the case that an indigenous capability will never be full developed. Small island countries which have land areas less than 500 km2, populations of 100,000 or less and which have extremely limited infrastructure, manpower and financial resources, but for whom marine resources are the fundamental basis of their traditional and monetary economy, may require special consideration in any global review of the role of marine science and services. For such countries it is vital that marine science is not treated separately from other areas of development and that realistic and innovative approaches be taken to solve the problems and enhance the opportunities for sustainable development provided by their marine environments. For such countries, needs in marine science will be quite different from those of over-populated coastal states in large continental areas.

34. The charter of economic rights and duties helped to shape the UN Convention on the Law of the Sea which aims at a more just and equitable order that may meet the needs and interests of developing countries. The Convention encourages the co-operation of States, either directly or through international organizations concerned with marine scientific research, and the transfer of knowledge and technology. The Convention has now been signed by 159 States and it is important to note that the preamble to the Convention refers to the desirability of establishing:

> *"a legal order for the seas and oceans which will promote the peaceful use of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their resources and the study and preservation of the marine environment".*

35. Marine science research and the development of marine technologies receive prominence in the Convention and approximately 100 of the 320 articles deal with matters relating to ocean science, constituting a legal framework for the adoption of bilateral, regional and global agreements for international co-

operation. The Convention stipulates that co-operation shall be based on reciprocity and mutual advantage, i.e., partnership, and thus provide an opportunity for improving the present situation.

36. Partnership has therefore taken on a new meaning, one of concerted action and for which international co-operation is vital. Such co-operation must be based on clearly defined rights and obligations, and execution of activities must be guided by common objectives and mutual interests. In addition the complexity and magnitude of modern research programmes in marine science, together with the requirements for systematic ocean observations and monitoring and data exchange and the scale of investments required, all dictate the necessity for widespread international co-operation if these programmes are to succeed.

37. Many of the major fish stocks of the world's oceans are utilized by several states and sound management of such resources can only take place on a regional co-operative basis. This principle is recognized in article 61 which provides for international co-operation to ensure that the living resources within a State's Exclusive Economic Zone are not endangered by over-exploitation. Potential transfer of pollutants from one ocean area to another may require international regulation and control and to effect such control, scientific data on the nature of the pollutant and the physical processes involved in its transfer must be made available if an international agreement is to be reached to maintain the quality of the marine environment as required under the Convention.

38. Once the new Convention of the Law of the Sea enters into force scientific research within the 200 nautical mile, Exclusive Economic Zones, may only be conducted with the consent of the coastal state concerned. Although the Convention is not yet in force, the consent regime is already being practiced.

39. The last Session of the Third United Nations Conference on the Law of the Sea (Jamaica, April 1982) adopted the Convention on the Law of the Sea, including the Resolution "on Development of National Marine Science, Technology and Ocean Service Infrastructures (Resolution IV, Annex VI), adopted by the last session of UNCLOS). The Resolution, *inter alia*, recommended that

> *"all competent international organizations within the United Nations system expand programmes within their respective fields of competence for assistance to developing countries in the field of marine science technology and ocean services and co-ordinate their efforts on a system-wide basis in the implementation of such programmes, paying particular attention to the special needs of the developing countries, whether coastal, land-locked or geographically disadvantaged".*

It also recommended that

> *"the World Bank, the regional banks, the United Nations Development Programme, the United Nations Financing System for Science and Technology and other multilateral funding agencies augment and co-ordinate their operations for the provision of funds to developing countries for the preparation and implementation of major programmes of assistance in strengthening their marine science technology and ocean services".*

40. The UNESCO/IOC Comprehensive Plan for a Major Assistance Programme to Enhance Marine Science Capabilities of Developing Countries intends to respond to the spirit and objectives of this Resolution.

41. Substantial assistance to developing Member States of IOC and others to improve their capabilities in marine science and related aspects is necessary because:

(i) extended maritime jurisdiction by coastal states has created a situation where self-reliance in marine science is needed to ensure that their new rights, especially to control resource exploration and exploitation, and the conduct of research can be exercised and that they can benefit from this new situation for socio-economic development;

(ii) diversification of ocean uses and the evolution of national goals in marine affairs call for flexibility in the use of available national facilities and skills in order that States are able to respond to an array of problems;

(iii) increasingly, effective scientific input to development activities calls for multidisciplinary and interdisciplinary research with multiple applications;

(iv) negotiations concerning access by others to zones of national jurisdiction make it in the interests of both developing coastal states and researching industrialized states wishing for access that there be competent scientific bodies on both sides. A similar argument applies to the transfer of marine technology;

(v) as a result of jurisdictional changes in the ocean regime, countries will again find it increasingly necessary to take an active part in bilateral and multilateral arrangements to ensure effective use and conservation of shared resources and to deal with major oceanic phenomena having bearing upon their economies;

(vi) countries are faced, at the political level, with the need to formulate marine policies for development and management of large new areas of territory under state control, and this calls for substantial inputs of scientific information and oceanographic data and thus for proper formulation of national marine science policy.

42. Improved capability involves strengthening of marine science infrastructures, including increases in quality and numbers of research institutions, researchers, vessels, etc., to ensure that facilities and manpower are efficiently used, that national and international support is obtained for strengthening them, and to ensure that the scientific community is able to contribute effectively to formulation and execution of marine policy. Strengthening of this organizational infrastructure includes establishment of appropriate relations between it and the other national bodies concerned with science policy, scientific research, science services, marine affairs, higher education, public information and technology transfer.

43. It is therefore desirable for each state, according to its specific needs, customs and governmental structure, to possess a mechanism for co-ordination and stimulation of marine science internally and to interface with other national infrastructures as indicated above, as well as with international organizations concerned with marine science, ocean services and technology.

44. The essential characteristics of such a mechanisms include: management of some funds; representation of all relevant governmental departments, universities and research institutions, as well as scientific disciplines; and access to national marine data and information systems and common facilities; ability to provide advice on giving or withholding formal agreement to marine scientific research activities under the consent regime in areas under the states' jurisdiction; a competence to advise on the formulation of ocean policies and goals; as well as authority to ensure the participation of specific scientific groups and facilities in agreed international programmes. A model for such a key component of more complex arrangements is a high level national oceanographic co-ordinating body which might also become the national corresponding body for IOC and other international activities in the field of marine sciences.

45. It is argued that for self-reliance in the long-term, the national marine science community must become critically numerous and diversified and that this goal can be promoted by regional pooling of some facilities and activities and by regional collaboration.

46. Further, developing countries should be involved in basic, as well as applied research, rather than merely being beneficiaries of the eventual application of scientific discoveries, and they need assistance in this regard.

47. Assistance to states emanating from bilateral and international sources to the ends envisaged, including funds which could be under the control of national oceanographic commissions or other appropriate national bodies, should be channelled through the projects associated with the regional and sub-regional research programmes, for instance those of UNESCO and IOC. These funds should supplement those already made from the national marine scientific activities and the contributions of those countries to regional activities. It is expected that these latter, because of new conditions created by extensions of jurisdiction, may be numerous and frequently bilateral or trilateral among neighbouring states.

48. The introduction and the international endorsement of the EEZs have implied the addition of a new territory or region to the coastal States. This new territory has created new opportunities and responsibilities for the coastal countries. In order for those opportunities to be used it is, as on land, necessary to occupy the territory. This is now gradually happening. The next century will see a growing occupation of the ocean space. The traditional uses will be adjusted and expanded. Tourism for health, recreation, sport, combined with the leisure of the local population will be one area: but tourism adjusted to sustained development, or so-called "green-tourism". An associated expansion of the use of the ocean as a transportation means of goods and human beings is clearly to be expected. This will also occur in light of fossil fuel limitations. The renewable energy form in the wind can best, and perhaps only, be used for transportation at sea and along the coasts. Ocean going research vessels driven through sail technology are already in use; likewise for tourism and recreation. These uses will expand. The thrill of sailing in a large vessel is exceptional for young people and for their physical and psychological training.

49. The associated infractructures and service arrangements will be of a new kind: harbours, supply facilities adjusted to new types of ocean transportation and to new human requirements.

50. The use of marine non-living resources, sand and gravel, to protect coastlines and low-lying land from the sea, is practiced in Holland and elsewhere. It can be expected to find its use also in other parts of the world. This will also require new technologies and structures.

51. The associated scientific and technological needs will have to be met, and likewise the administrative. There is a need for a cross-sectoral fertilization and exchange - with a breaking down of traditional barriers. Here, developing countries have at least one advantage over developed countries.

II. FRAMEWORK : THE LAW OF THE SEA

52. The protection of the high seas and of their resources obviously requires a ***global approach***. The exploitable living and non-living resources of the Southern Ocean require a specially careful management regime.

53. The seas have no physical boundaries to prevent movement of polluted waters. Therefore, global or regional strategies are needed to ***control transboundary pollution from land-based sources***, including pollution reaching the marine environment through rivers and the atmosphere.

54. Accidents resulting in damage to the coastal and near-shore environment, such as the pollution caused by tanker accidents, cannot be completely avoided, but with the formulation and adequate implementation of ***contingency and emergency plans*** their environmental impact can be considerably mitigated.

55. The Law of the Sea Convention contains 320 articles and 9 annexes and has separate parts that deal with "Marine Scientific Research" and with "Development and Transfer of Marine Technology". The Convention will enter into force 12 months after the date of deposit of the sixtieth instrument of ratification or accession. Fifty-six countries have done so (October 1991).

56. The EEZs comprise most of the continental shelf areas, which contain almost all marine living resources, and where more than 90% of all fish are caught. Considering the relatively negative experience from past efforts to manage marine resources through international regimes, chances are that national "ownership" rights can promote a better sense of responsibility for the resources.

57. However, there are, according to the definitions of the Convention, a number of so called highly migratory species (e.g., tuna, marlins and marine mammals), that move between the high seas and the EEZs of different countries. These species constitute truly shared resources. The proper long-term conservation and management of these resources call for special arrangements and international co-operation. The Convention refers to the open seas as the High Seas which include (Article 86):

> *"... all parts of the sea that are not included in the Exclusive Economic Zone, in the territorial sea, or in the internal waters of a state, or in the archipelagic waters of an archipelagic State."*

All States have a right to engage in the exploitation of the living resources of the High Seas subject to the obligations of the Convention (Article 116), and the Convention calls on States to co-operate in the conservation and management of living resources of the High Seas. Thus, there is a need to develop international agreements setting out the special regulations needed to implement the overall goal of the Convention, i.e., the conservation and management of these shared living resources. To be effective, such agreements or conventions must be founded on a solid scientific basis and knowledge of the ecology (population dynamics) of these species, and on a political will on the part of the participating countries to create a system for co-operation that will ensure that the utilization of these species is sustainable and guarantees the long-term survival of the species.

58. The traditional "freedom of the seas" remains for 60% of the ocean. But for 42% of this, the deep sea beds, the resources located there are considered as the "common heritage of mankind". The Convention makes special and detailed provisions for regulating the exploitation of the resources on the seabed.

59. During 1990 a renewed interest in the Convention has been noted. Efforts are being made to find a consensualsolution for the problems arising from the articles regulating seabed mining. In the process leading up to the UN Conference on Environment and Development, it has been proposed that the conference should discuss the possibilities of a global structure/agreement to deal with the degradation of the marine environment stemming from land-based human activities (land-based pollution and destructive resources management). The global principles on the protection of the marine environment from various activities and sources of pollution in the UNCLOS text could form an important basis for this work.

60. Rational, sustainable utilization (including development, management and conservation) of marine resources is strongly dependant on the proper use of science and technology. Development of a resource depends on the application of scientific methods in assessment of the resource potential and on appropriate technology. Rational management (including conservation) especially of living resources must be based on detailed scientific information about the dynamics of the stocks, as well as on the evaluation of the interaction between living resources and on the surrounding biotic and abiotic environment. The role of marine science and appropriate technology in the utilization of living marine resources applies to both high technology and artisanal fisheries. The development of relevant scientific and technical competence is therefore of equal importance for all coastal states regardless of their respective level of development.

61. During the period of negotiations of the Law of the Sea Convention there was an increasing awareness among the developing countries of the need for the strengthening of their marine science and technology. This was reflected, for example, in one of the resolutions adopted and included in the Final Act of the Law of the Sea Conference. Annex VI notes that "if urgent measures are not taken, the marine scientific and technical gap between the developed and developing countries will widen further and thus endanger the very foundation of the new ocean regime". The resolution further urges industrialized countries to assist developing countries in the preparation of their marine science, technology and ocean service development programmes.

62. During recent years there has been a rapid increase in the level of technology applied to marine sciences, but also a levelling off in the growth of funding from both bilateral and multilateral sources. As a consequence, the gap between industrial and developing countries in the level of marine science and technology has in fact widened.

63. Countries from north and south, against the background of the huge and complicated marine issues, have gradually realized the need for co-operation and the mutual benefits that can be derived. Pooling of resources, sharing of information, education and training are all essential elements to create a foundation for the global approach necessary if the major outstanding uncertainties are to be narrowed down and a better basis for making informed decisions about the future shaped, so as to avoid further immense problems for the future due to the present actions.

64. Although all coastal states have local problems which require marine scientific research for their solution, they also have problems which can only be resolved by investigations on a wider geographical scale. Over the years, a pattern of international co-operative programmes has emerged and procedures for planning and implementing these have been worked out by groups of states. In parallel with this development, global co-operative programmes in the field of

ocean science and ocean services have been launched. As the number of developing states involved in regional programmes especially has increased, so have these regional programmes increasingly been directed toward solving problems addressing transnational oceanic phenomena of particular interest to those states. All developing coastal states, if they are engaged in marine science at all, are involved in various forms of international co-operation. Because of the nature of the marine environment, and the history of its use, some advanced countries are also participating in most of these programmes, even in regions to which they are not coastal. Inevitably, the more advanced countries obviously have contributed a large share of the effort to acquire relevant knowledge; many of the developing countries, on the other hand, have obviously difficulty in substantially contributing to these enterprises. Moreover, co-operative programmes are mutually beneficial, especially to the developing countries in so far as they provide an excellent opportunity for interaction and for strengthening of national infrastructures in various disciplines of marine sciences both in coastal and offshore waters.

65. Most international co-operative programmes require action at the regional level through provision of co-ordinating secretariats, regional data centres and some common research facilities. Most of the effort is, however, undertaken by the participating states. Usually, each state takes a specific share, geographically, in the investigations. In addition, selected national units will commonly perform international functions for the duration of the programme and sometimes after it. This often calls for international funding to strengthen them. Financial help can make a substantial contribution to such programmes when provided through regional/sub-regional aid projects for the particular purpose of strengthening the participation from the developing states in such a way that their national capabilities in marine science are permanently enhanced.

66. The Law of the Sea specifically requires states to co-operate on a global and, as appropriate, on a regional basis in the protection and preservation of the marine environment, taking into account characteristic regional features (ref. Article 197). This also implies co-operation in and promotion of marine scientific research and observations for common use. It is also specifically stated that states and competent international organizations shall promote international co-operation in marine scientific research for peaceful purposes (ref. Article 242). This co-operation can occur through inclusion of bilateral and multilateral agreements, so as to create favourable conditions for the conduct of marine research and integrate efforts of scientists studying the essemce of phenomena and processes occurring in the marine environment and the inter-relationships between them (ref. Article 243).

67. The Convention likewise stimulates international co-operation for the development and transfer of marine technology, through existing bilateral, regional and multilateral programmes and through expanded and new programmes, in order to facilitate marine research and appropriate international funding for ocean research and development (ref. Article 270). In this context the establishment of national marine scientific and technological research centres and the strengthening of existing national centres is promoted (ref. Article 275). Adequate support is encouraged to facilitate the establishment and strengthening of such national centres and to provide advanced training facilities and necessary equipment, skills and know-how, as well as technical experts to States which may need and request such assistance (ref. Article 273).

68. The promotion of the establishment of regional marine scientific and technological research centres, particularly in developing states, is also encouraged, in order to stimulate and advance the conduct of marine scientific research by developing states and foster the transfer of technology (ref. Article 276). Examples of the functions of such regional centres are also explicitly given (ref. Article 277).

69. It is clear that these mechanisms should be used. Several endeavours are underway - including in the Mediterranean and the Wider Caribbean. Regional networks are being established through regional research and observation programmes, addressing identified priorities. This mechanism is very viable - but requires increased financial support on an inter-regional basis. The multilateral funding mechanism needs strengthening.

III. MARINE SCIENCE AND THE GLOBAL FUTURE

70. ***Sustaining human life and well-being requires development and a healthy environment.*** Development can become difficult to achieve if natural resources are

depleted or the environment degraded. Therefore, the *ultimate goal* of all strategies for the development and protection of the oceans, coastal waters and their resources should be to ensure their *rational use*. In case of *renewable resources*, rational use must imply *sustainable use*. The use of *non-renewable resources*, should provide an economic basis for build-up of activities and conditions that will ensure or contribute to a *long-term and sustainable socio-economic development*, once the non-renewable resources are exhausted. Consequently, remedies for the present and anticipated environmental and developmental problems should be designed with that goal in mind, and their appropriateness should be judged from the degree in which they managed to achieve that goal.

71. Today humankind faces an unprecedented situation. In the span of a single human generation, the Earth's life-sustaining environment may change more rapidly than it has ever done over any comparable period of human history; this possible change is mainly generated by humankind itself. How can science and observations help? Can improved predictions be obtained? Or must we act on the basis of an insurance policy? One thing is clear - we must act.

Ocean-Atmosphere-Climate

72. The ocean plays a role in the climate system which is complementary and of comparable importance to that of the atmosphere. It stores heat and releases it later, and often in a different place. It transports heat in amounts comparable with atmospheric transport. It both absorbs and releases carbon dioxide.

73. Understanding and prediction of the behavior of the climate system requires understanding and prediction of the behavior of the ocean. To perform this task requires both modelling and monitoring of the ocean. There is every reason to believe that the ocean is now changing, in response to climate changes over the past few hundred years. It can be expected to change further as anthropogenic influences become increasingly marked. The effect of the ocean on the atmosphere could be either to moderate or to intensify these changes.

74. The expected impact of predicted climate changes will exacerbate the present problems and may, in areas such as low-lying islands and coastal zones, significantly influence or even imperil their future development and use. The predicted climate change will certainly affect marine living resources in many ways. Large scale changes in total marine fisheries production are not expected, although individual stocks may suffer. Mariculture will probably be more affected. Tropical up-welling zones, which produce large amount of fish resources may shift polewards by hundreds of kilometers. The year-to-year variability of the resources they support may increase and the increased plankton productivity may reduce oxygen levels and lead to anoxic situations. The increased ultraviolet radiation related to ozone layer depletion may lead, according to some estimates, to detrimental effects on some shallow water ecosystems such as coral reefs, and may affect plankton production.

75. Global warming is expected to occur as a result of increasing atmospheric concentrations of greenhouse gases, especially carbon dioxide (CO_2), methane (CH_4), chloro-fluorocarbons (CFCs) and nitrous oxide (N_2O). The increased concentrations of these gases are caused by various human activities, e.g., the use of fossil fuels, intense agriculture, deforestation and the increase of the human populations. These increases will enhance the natural greenhouse effect, which keeps the earth warmer than it would otherwise be. The increase of methane in the atmosphere over the last 1-200 years parallels the global population increase.

76. The Second World Climate Conference (Geneva, October 1990) concluded, partly on the basis of the IPCC report, that without actions taken to reduce the emissions of the greenhouse gases, global warming will reach 2-5 degrees C over the next century. This is a rate of change unprecedented in the last 10,000 years.

77. The global warming is expected to be accompanied by a sea-level rise of 65 cm +/- 35 cm by the end of the 21st Century. This should be added to the increase in global sea-level of 10-20 cm that has occurred over the last 100 years. Global warming may also modify ocean circulation, changing the heat transport, and change marine ecosystems, with considerable socio-economic consequences.

78. Although a consensus seems to exist among scientists that climate change will occur as a result of increasing concentrations of greenhouse gases, there is considerable scientific uncertainty with regard to the details of these climate changes (e.g., geographical distribution, magnitude at different latitudes, and ecological as well as socio-economic effects).

79. Intensified research and observation efforts during the coming decades will be of crucial importance to increase our understanding of the processes and their role in global change. This was also recognized by the Second World Climate Conference, which emphasized that the uncertainties in the projections of future climate change can only be narrowed down through research addressing the following priority areas :

- clouds and the hydrological cycle;
- greenhouse gases and the global carbon and bio-geochemical cycles;
- oceans : physical, chemical and biological aspects; and exchanges with the atmosphere;
- paleo-climatic studies;
- polar ice sheets and sea ice; and
- terrestrial ecosystems.

80. The Second World Climate Conference furthermore stressed the need to create a Global Climate Observing System (GCOS) with a global ocean component. This should, to the extent possible, be built upon the already existing observing system components. The development of a Global Ocean Observing System (GOOS) of physical, chemical and biological measurements, as part of GCOS, should be accelerated.

81. Although these developments should not be seen as new, substantial resources will have to be allocated to these tasks if reliable data for assessments and support to decision making are to be generated from the various programmes within a reasonable time-frame and progress made in reducing the uncertainties in the predictions. These resources will have to be provided to national programmes and international activities as well as on the truly global programmes.

Coastal Zones, Uses and Marine Resources

82. **Living Resources** : there has been a drastic increase in the total fish catch since the end of World War II. Until about 1970, the annual increase in the catch was about 4-5%. The increase levelled off during the 1970s to an average of about 1-2%, due to e.g., over-exploitation of some stocks and effects of natural phenomena like "El Nino". During the 1980s there has again been a strong upward trend in the global fisheries with an annual increase of 6-7%. The renewed increase can be attributed primarily to increased landing of 4 species; Peruvian anchovy, South American sardine, Japanese sardine and the Alaskan pollack. It should, however, be borne in mind that populations of anchovies, sardines and other "shoaling pelagic" species are notoriously unstable. In the past, they have shown large fluctuations caused by changes of e.g., currents, up-wellings and other environmental factors. Thus the catch for 1989/90 shows a global decrease of about 1-2% .

83. In absolute numbers the catches have almost quintupled since 1950. The total catch of marine and fresh water fish has increased from 19.8 million tons to 97.4 million tons in 1988. The marine catches are by far the greatest. The landing of marine fish increased during the period 1950-1988 from 17.6 million tons to 84 million tons. It is believed that the world's marine and freshwater fisheries will soon approach what many biologists think is the limit of sustainable yield. FAO has estimated this level to be in the order of 100 million tons annually. The continued health of the oceans, long-term livelihood of the millions employed in fishing as well as the survival of large parts of the developing countries populations, depend on harvests that do not exceed this sustainable yield. However, despite this, many regional fisheries in fishing areas such as the Northwest Pacific, the Barents Sea and the Southern Ocean show signs of drastic overfishing.

84. Biologically, the most productive areas of the ocean are the coastal zones, where nutrients are washed out from land or transported up to the sunlit surface layers by upwelling water. The continental shelf areas yielded 97,5% of the world's marine fish catch in 1987.

85. **Coastal Zones** : The nature of the problems affecting the marine and coastal environment has not altered greatly in the past decades. However, the incidence and extent of human interference in the coastal areas as well as our perception of the main threats and corresponding solutions have changed markedly on the basis of knowledge and experience accumulated over the same period. Today the environmental problems are recognized as problems stemming from inadequate or improper development whose ultimate solution should be sought in resolving conflicting interests for space and resources in the framework of an environmentally sound economic development.

86. Although the open oceans, apart from some living resources, seem to be still largely unaffected, the physical and ecological degradation of coastal areas and the increase of pollution in near-shore waters from land-based sources are accelerating at an alarming pace. The often dramatic and irreversible alteration of natural coastal ecosystems and the extensive pollution of the sea are primarily caused by the rapid growth of coastal settlements, the expansion of recreational areas, and the concentration of industrial development in coastal zones, accompanied by inadequate environmental and economic planning. The situation in many enclosed and semi-enclosed seas, largely due to pollution from land-based sources, or from major maritime accidents, such as the one involving the Exxon Valdez, is of particular concern.

87. Regional assessments of the state of the marine environment list a wide range of human activities that have serious negative effects on the coastal ecosystems. Among these are:

- Soil erosion as a consequence of present land use practices in agriculture and forestry (deforestation). The resulting increase in the sediment and silt loads in the coastal waters leads to increased turbidity of coastal waters, and enhanced sedimentation on productive habitats such as coral reefs, and seagrass meadows. These effects have been ranked as possibly the greatest threat to the coastal waters in large parts of East Africa, South-East Asia and South Asia. Negative effects of this sort are also caused by present methods of development of coastal areas, including activities like land reclamation, dredging and building of harbours, conversion of mangrove forests and coastal wetlands for agriculture or aquaculture.

- Discharges (emissions) of sewage, pesticides, oil and industrial wastes.

- Destructive fishing methods, e.g., the use of explosives or poisons, destroying coral reefs.

- Tourism, especially mass-tourism, as presently practiced, negatively affects the coastal environment through land "development", discharges of sewage and the collection by tourists as well as local populations of corals, shells, sea stars and other organisms.

- Commercial export of reef organisms.

- Discharges of untreated or insufficiently treated sewage. Such discharges can cause a number of negative effects including decreased oxygen content of the water, causing eutrophication and algal blooms (e.g., of toxic plankton algae like Gonyaulax and Phyrodinium), increased turbidity which diminishes light penetration, and contamination of seafood by pathogenic micro-organisms.

88. The protection of the marine and coastal environment is reflected in the national legislation of most countries and in numerous international agreements. However, the provisions of these legislative acts are not applied efficiently to guarantee development without undermining the natural resource-base.

89. Public awareness about the problems of the marine and coastal environment is still generally weak although in some countries it plays an important and highly visible role in mobilizing support from broad segments of the population for the necessary societal decision-making needed for the development of that environment and rational utilization of its resources.

90. The present problems are most evident in coastal and near-shore areas under the direct influence of man's activities. Although seemingly local in nature, these problems are widespread and are evident even at sites far away from their origin and only globally applied strategies implemented locally have a chance to achieve long-term solutions. The type and intensity of measures and policies, if they are to be effective, must be made in response to the actual situation, keeping in mind that a solution at one site should not create a nuisance elsewhere. Consequently, the most cost-effective remedies should be sought through action on local and national levels, undertaken in the framework and as part of wider regional and global development strategies, including transfer of the necessary resources, technology, knowledge and skills to the disadvantaged countries. Tourism and transport can be widely developed for the marine environment but this will require related untraditional thinking in the organization.

91. A major threat to the living marine resources in the coastal regions of the world is the increasing degradation of the marine environment caused by pollution and the destruction of coastal habitats (wetlands, mangroves, coral reefs, estuaries, etc.) which are of crucial importance to the coastal marine ecosystems. Everywhere around the world the coastal zones of the ocean are under growing pressure from expanding human populations. Estimates show that, by the year 2000, 75 per cent of the world's population of about 6 billion people, will live in the narrow coastal strips (up to 60 km wide). In densely populated regions like South-East Asia the figure will be even higher.

92. Although most of the decisions on coastal planning and management must be taken on the national level, many of the present problems are of regional (or even global) importance (e.g., occurring in many countries throughout a region, affecting fish stocks shared by several countries). Thus, there is a strong need for a strengthened international regional co-operation, constituting a regional framework for the jig-saw puzzle made up of the national programmes. Such co-operation can provide a common basis for e.g.,

- common management decisions for the protection and management of the coastal marine resources on a regional level;
- exchange of information on national experiences;
- regional scientific research and monitoring programmes;
- education and training;
- development of methodology for planning and management;
- transfer of technology and resources (e.g., if the regional programmes can attract the interest of bilateral donors as well as the multilateral development agencies such as the World Bank and the Regional Development Banks).

93. **Non-Living Resources** : Research on the processes leading to the deposition of various minerals in the coastal zones, on the continental shelves, on the continental margins and in the deep ocean are important for the understanding of the physical, chemical and biological processes in the ocean. A basic understanding of sedimentary environments, sea-level changes, and formation of resources is necessary if a comprehensive picture of the factors influencing the nature and distribution of marine non-living resources is to be developed.

94. The exploitation of marine aggregates is by far the largest marine mining operation presently going on. Resources of sand and gravel are estimated to be very large, off the northeastern coast of the US alone in the order of 400 billion tons. Such resources are being used e.g., in Holland to replenish and limit beach erosion generated through sea level changes.

95. In some areas carbonate is extracted from the seafloor to be used in the cement industry and for construction purposes. In temperate areas the carbonate is mostly found in the form of shell banks, while in tropical and subtropical areas, coral reefs (living or dead) are extensively used. Carbonate mining operations are taking place in e.g., Western Europe, the US, India, Brazil, Australia, in the South Pacific and in the Caribbean.

96. Placer deposits can be formed when minerals with a high specific gravity are selectively concentrated in response to the hydrodynamic conditions occurring in high energy environments like rivers, beaches and estuaries. Placer deposits rich in elements such as titanium, tin, and gold exist in or near to the coastal zone in various parts of the world, extending across the continental margin in several places.

97. The list below gives some examples of presently operating commercial enterprises in various countries and regions:

SE, SW Australia, Malaysia, India China, Sri Lanka, the US, South Africa	ilmenite, rutile, zircon monazite (heavy metal grains)
SE Asia, (Malaysia, Thailand, Indonesia) E. Australia, Siberia	tin (placer mineral in alluvial gravels and older gravels)
Alaska	gold (dredging of goldbearing sediments in old river channels)
Namibia, South Africa	diamonds

98. Fertilizers minerals in the form of phosphate-rich and potash-rich sediments exist on several continental margins. Although not exploited at present, they represent an important resource for fertilizers in the future. Areas with deposits likely to be exploited in the future include the continental margins off Chile and Peru, South West Africa and Eastern Australia where phosphorites are forming at the present time, and Southeastern USA, Southern California, Northern Mexico, New Zealand, Portugal, and Morocco where extensive residual phosphate deposits are found.

99. The deep ocean manganese-rich nodules and crusts, first discovered in the 1870's during the Challenger Expedition, have attracted a lot of attention during the last decades. They have been subject to extensive investigations for scientific reasons as well as for their potential commercial value. Polymetallic nodules are found at depths between 3,000 and 6,000 meters over large areas of the deep sea floor. They are most abundant in the central and southwest Pacific, and the central and southern Indian Ocean. In this context it should be underlined that it is not the manganese content as such of the nodules that is of possible commercial interest but the nickel, copper and cobalt found together with the manganese in the nodules. Nodules of potential economic significance are those with an Ni+Cu content of more than 2.5 per cent.

100. Already in the 1960s scientists predicted the existence of hot springs on the ocean ridges. It was, however, not until 1977 that an expedition found such a spring on a ridge area north of the Galapagos Islands. At a depth of 2 600 meters the light from the research submarine revealed a surprisingly rich life consisting of gigantic carmosin-red worms, white crabs and large clams using the chemical energy (with bacteria as the transforming intermediate organisms) in the hydrogen-sulphide contained in the mineral rich water of the hot vents.

101. Polymetallic sulphides are deposited in and around the hot vents which can form "chimneys" or "black smokers" up to a height of 30 meters. From these metal-bearing brines are discharged at temperatures of up to 350C. "Smokers" of this kind have now been discovered on the East Pacific Rise, the mid Atlantic Ridge and in the southwest Pacific.

The deposits from these vents are of two types:

- sediments rich in copper, zinc, lead and other metals, which are precipitated out from the plume; these deposits may form up to hundred of kilometers from the vent system;
- solid chimneys forming tree-like columns over areas up to several kilometers from the springs, with sediment crusts as thick as 40 meters and containing up to 10 per cent copper, as well as silver, zinc, lead, tin, vanadium and cobalt.

102. The metal concentrations in the deposits are in many cases higher than in onshore deposits that are mined economically successfully.

103. **Oil and gas:** Oil is a naturally occurring, complex, mixture of organic compounds, resulting from the degradation and transformation of plant and animal remains under special geological conditions, e.g., high temperatures and pressure. The reservoirs in which oil is found consist of so-called porous and permeable sedimentary bed-rocks.

104. The physical and chemical properties of oil from different reservoirs, and also from different depths of the same reservoir, often vary considerably. An exact definition of oil is therefore impossible.

105. Crude oil may vary from a light, almost colourless liquid to a sticky, black mass, as in the case of tar. Most crude oils are, however, dark brown to blackish and flow easily.

106. Crude oil contains many thousands of different chemical components. The largest group of these compounds are called "hydrocarbons", as they are composed entirely of the elements carbon and hydrogen. Other groups of substances also contain sulphur, nitrogen and oxygen. Most crude oils also contain traces of various metals. Most crude oils contain over 95% hydrocarbons. In some cases, however, the hydrocarbon content can be as low as 50%

107. Hydrocarbons are divided chemically into three general classes: aliphatic, alicyclic and aromatic compounds. Each of the classes can be further divided into sub-classes.

108. Aliphatic hydrocarbons are built of open chain, straight or branched carbon skeletons. These may be fully satured with hydrogen, the so-called satured aliphatic hydrocarbons, or alkanes, or they may be somewhat deficient in hydrogen, in which case they are said to be unsatured compounds (alkenes, alkynes). Alicyclin hydrocarbons contain one or more ring structures in the carbon chain, and are called naphthenes. The rings may contain from three to more than twenty carbon atoms, and both satured and unsatured naphthenes exist. The aromatic hydrocarbons (aromatics) all contain one or more benzene rings (rings with six carbon atoms and six hydrogen atoms in a special unsatured complex).

109. The oil and gas industries were pioneers in exploiting coastal marine non-living resources, beginning off California already in 1891. However, sub-sea exploitation of oil and gas began in earnest in the 1920s. Although many individual fields were developed, each was small and located in shallow waters near the coast.

110. Technological developments allowed the exploration and exploitation to move further off-shore into deeper waters in the 1960s. This development continued during the 1970s as the cost of land-based oil and natural gas soared. Drilling operations are now being conducted even in such hostile environments as the Grand Banks, parts of Georges bank and the Beaufort Sea. Plans for drilling in the Barents Sea are also far advanced and even the continental shelf around Antarctica has been suggested as a possible future area for exploitation.

111. Exploration and production of oil and gas is without comparison the most important ocean engineering activity especially considering the spectacular technological achievements that the been made and the economic significance of the industries.

112. A large number of offshore structures (platforms) are being used during the exploration and exploitation phases of the oil and gas wells. The type of platform varies with the water depth, the conditions of the sea bed, the environmental parameters like waves and currents and the depth of the bedrock layer from which the oil and gas is pumped.

113. Various suggestions have been put forward on how oil could be extracted from deposits at depths larger than 500 metres. Beyond this depth platforms tend to be unstable. One proposal has been to move the whole production plant to the sea bed instead.

114. Roughly one fourth of the world's oil production comes from offshore areas being 578 and 724 million tons in 1978 and 1988, respectively. World offshore crude oil output has increased by 27 percent during the last decade. The greatest production increases have taken place in Angola, Brazil, Mexico and the North Sea oil-producing countries.

115. During the same period world's offshore gas production grew by 19 percent being 267 and 318 billion m^3 in 1978 and 1980, respectively, and showing an increase in all regions except Afric and North and Central America.

116. Oil and oil products are discharged to the marine environment from a number of sources. The total input of oil to the world's oceans is difficult to determine precisely. Most estimates indicate a volume of between 3 and 4 million tons per year. About half of this comes from land-based sources and half is of marine origin.

117. Ocean Thermal Energy Conversion (OTEC), Wave Energy and Tidal Energy are three forms of ocean energy that seems to be most promising and likely to be taken into large-scale operation within the near future.

118. OTEC is best suited for use in the tropics as it utilizes the temperature difference between the warm surface water of around 28°C and the cold water of around 8°C at depth of approximately 800 meters. The global OTEC potential has been estimated at 10 million MW which is about 10 times the total world power production. OTEC has been proven feasible in small-scale demonstration plants. The deep ocean water pumped up, which is rich in nutrients, could also be used for mariculture - although some concern has been expressed about the possible eutrophication effects from pumping very large quantities of nutrient-rich deep water to the surface.

119. Countries involved in OTEC development include the US, Japan, France, Sweden, the Netherlands and India.

120. Wave energy in the form of wind waves could be developed into an important renewable energy source along certain coasts. The global wave energy potential has been estimated at 2.5 million MW. Pilot plants (0.5 MW) using the oscillating water column (OWC) technique have been built and proven. Research on wave energy is undertaken in e.g. the US, Japan, Sweden, Norway, India and the UK.

121. Tidal range of 5 meters or more is considered necessary to make tidal energy extraction economically feasible. Even with these minimum requirements there are hundreds, possibly even thousands of sites around the world with this tidal range. On the other hand concern has been expressed about the environmental effects of putting barriers and other constructions across bays and estuaries thus influencing the ecological balance in the often very important and productive wetlands, tidal plains and marshes in the inner parts of the bays and estuaries.

IV. SUSTAINABLE FUTURE

122. The concept of Sustainable Development was defined by the World Commission for Environment (WCED) as ***"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"***.

123. Decisions on how to put our planet on the sustainable track, that everyone seems to agree upon, must be based on much better database and understanding of the basic atmospheric, terrestrial and marine systems and their interactions. This is true not least with regard to our knowledge about the ocean. The specific role of the ocean in shaping the earth's environment for life needs to be significantly better understood.

124. The policies, measures and arrangements for the protection and use of the marine and coastal environment, if they are to be rational and thus effective in the long term, should be based on an improved understanding of marine and coastal ecology, including ecosystem dynamics; of the relevant ocean processes; and of their interaction with terrestrial and atmospheric systems.

125. The capabilities of most countries, especially the developing ones, are still generally insufficient to cope adequately with the full complexity of the assessment of the problems facing their marine and coastal environment and the rational management of their resources. National institutional structures are generally too weak and lack the interdisciplinary expertise needed for effective action. This weakness of national structures also seriously hampers the effective participation of many countries in international efforts designed to protect and develop the marine and coastal environment.

126. The national institutions in charge of environmental protection in many countries are usually weak or even nonexistent. Their influence on national development plans is frequently only of marginal importance. Without creating strong national infrastructures, equipped with interdisciplinary expertise, and without giving them access to the circles where decisions relevant to the protection of environment are made, no effective protection of coastal and marine environments can be expected.

127. The protection and development of seas and coastal areas require a variety of expertise, and above all a good grasp of the cross-sectoral nature of environmental protection. While narrow, sectoral technical expertise exists in most countries, greater efforts should be devoted to the training of experts in interdisciplinary skills.

128. The new technology within computer sciences, satellite communication provides opportunities for enhanced international co-operation including co-operation between developed and developing countries. Few developing countries can, however, afford the modern instruments regarded as essential by the industrialized countries for conducting modern scientific research. Thus, the average scientist working in developing countries today has only limited access to these facilities. Only if access to these technologies is shared within the global scientific community, e.g. through comprehensive programmes on training, education, transfer of technology and establishment of partnerships, can an improved and equitable foundation for the necessary international research programmes be created. However, if access to these new technologies is not facilitated in this way there is, however, a serious risk that the new generation of sophisticated instruments within the marine sciences will lead to a widening gap between countries at a time when co-operation and participation of all coastal countries are more essential than ever to meet the challenges facing humankind.

129. In general governments are very reluctant to accept scientific results as a basis for management decisions unless their own scientists have been fully involved in the programmes designed and executed to provide the scientific background. From the point of view of protection of the marine environment and management of shared resources, it is therefore in the common interest of all countries to ensure a high scientific standard in all coastal nations. This further strengthens the argument for the development of comprehensive multilateral as well as bilateral assistance programmes in marine sciences.

130. Effective protection of the oceans can be achieved only through a high level of intergovernmental co-operation. It is essential therefore to strengthen and expand the multilateral programmes. Agreements designed to protect the marine and coastal environment according to the specific needs of the countries must be part of arrangements supporting intergovernmental co-operation.

131. Although transfer of technology, experience and data, provision of training, as well as financial assistance, preferential treatment and compensation for damage usually figure among the provisions of existing international agreements, the developing countries have benefitted relatively little from such provisions. Therefore fostering of global solidarity must be an essential element of all international agreements.

132. Applied science cannot exist without science itself. Science will play an increasingly important role in decision making. How otherwise deal with the environmental, economical, developmental crises ? Information and knowledge, selected and tested are needed. The scientifically trained intellect is required also to persuade and convince politicians and populations to deal with problems of the present so as to help avoid disasters for the future.