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Description of some types of marine technology and possible methods for their transfer: report of the Secretary-General

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States shall also take such other measures as may be necessary to prevent, reduce and control pollution of the marine environment from land-based sources.

2. States shall endeavour to harmonize their national policies at the appropriate regional level.

3. States, acting in particular through the appropriate intergovernmental organizations or by diplomatic conference, shall endeavour to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine environment from land-based sources.

[or]

3. States, acting in particular through the appropriate intergovernmental organizations or by diplomatic conference, shall endeavour to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine environment from land-based sources, taking into account characteristic regional features, the economic capacity of developing countries and their need for economic development.

4. Laws, regulations and measures, and rules, standards and recommended pratices and procedures referred to in paragraphs 1 and 3 respectively shall include those designed to minimize to the fullest possible extent the release of toxic and harmful substances, especially persistent substances, into the marine environment.

XI. *Draft article on pollution from dumping of wastes at sea* (See CRP/MP/20)

1. States shall establish national laws and regulations to prevent, reduce and control pollution of the marine environment from dumping[55] of wastes and other matters. States shall also take such other measures as may be necessary to prevent, reduce and control such pollution.

Such laws, regulations and measures shall ensure that dumping is not carried out without the permission of the competent authorities of States.

2. States acting in particular through the competent[56] intergovernmental organizations or by diplomatic conference, shall endeavour to establish as soon as possible and to the extent that they are not already in existence, global and regional rules, standards and recommended practices and procedures to prevent, reduce and control pollution of the marine environment by dumping of wastes and other matter.

3. Dumping of wastes and other matter within (. . .)[57] shall not be carried out without the express approval of the coastal State, which has the exclusive[58] right to permit, regulate and control[59] such dumping.[60]

4. . . .[61]

55 In the consideration of this subject, the concept of "dumping" was used in substance as found in the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, signed in London in 1972. The need to include a definition of dumping, the exact text thereof for the purpose of this Convention and its placing will be the subject of future consideration.

56 Some delegations suggested that the meaning of this word should be clarified.

57 Area to be determined at a later stage.

58 It was understood that this did not limit the right of other States to establish additional or stricter conditions or to prohibit entirely the dumping of wastes and other matter by ships flying their flag, ships or aircraft of their registry or ships or aircraft loading within their territory, including their ports or offshore terminals.

59 It was understood that this paragraph has to be reviewed in the light of the decision taken on enforcement.

60 The paragraphs in document CRP/MP/20/Add.1 (contained in document A/CONF.62/C.3/L.30) have neither been approved nor rejected. They will be considered at the next session of the Conference.

61 This paragraph was not examined due to lack of time. The texts for this paragraph will be considered at the next session of the Conference and for this purpose they have been recorded in document A/CONF.62/C.3/L.30.

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Description of some types of marine technology and possible methods for their transfer: report of the Secretary-General

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Preface

During the Caracas session of the Third United Nations Conference on the Law of the Sea, the Third Committee requested the Secretary-General to provide additional information describing the various types of marine technology and the possibilities for their transfer. Special reference was made to paragraph 60 of the report, "Problems of acquisition and transfer of marine technology"[62] which stressed the need for information regarding, for example, offshore oil and gas technology, deep sea mining, offshore structures, the extraction of dissolved chemicals from sea-water, undersea habitats and sand and gravel dredging.[63]

The present report consists of a brief description of the above technologies, reviewing the process of marine technology transfer and indicating possible methods for its promotion. Delegations should note that a summary of existing arrangements in the United Nations system for making available to interested countries, particularly the developing countries, information on advances in technology and the transfer of such technology to them, will be annexed to a forthcoming report on uses of the sea to be submitted to the Economic and Social Council at its fifty-ninth session.

I. Some notes on the process of marine technology transfer

1. The transfer of technology has become an important concern of the world community, as reflected in the section on transfer of technology in resolution 3202 (S-VI) of the sixth special session of the General Assembly which states that:

"All efforts should be made:

"*(a)* To formulate an international code of conduct for the transfer of technology corresponding to needs and conditions prevalent in developing countries;

"*(b)* To give access on improved terms to modern technology and to adapt that technology, as appropriate, to specific economic, social and ecological conditions and varying stages of development in developing countries;

"*(c)* To expand significantly the assistance from developed to developing countries in research and development programmes and in the creation of suitable indigenous technology;

"*(d)* To adapt commercial practices governing transfer of technology to the requirements of the developing countries and to prevent abuse of the rights of sellers;

"*(e)* To promote international co-operation in research and development in exploration and exploitation, conservation and the legitimate utilization of natural resources and all sources of energy.

In taking the above measures, the special needs of the least developed and land-locked countries should be borne in mind."

2. Marine technology is a product of man's attempts to control or adapt to the ocean environment by means of rationally organized systems of operation. To be sure, these systems encompass a wide range of activities–fishing, scientific research, transportation, communication and navigation, hydrocarbon and hard mineral exploitation, to name just a few–of greater or lesser degrees of sophistication and investment.

3. The word "technology", normally used as convenient shorthand, conceals at least five important ingredients: *(a)* hardware, *(b)*, operating procedures, *(c)*,maintenance procedures, *(d)* operating and maintenance skills, and *(e)* management capacity. In some cases the hardware may be the least important ingredient while skills and management capacity may be the most important.

4. In this regard it has been argued that the "most effective transfer seems to occur through direct contact and actual working together of individuals." Effective technology transfer usually requires adaptation of equipment or processes to local conditions, and this can best be done by arranging for experts and local people to work together in the actual location where the new technology is to be applied.[64]

5. The technology transfer process is conceived as a series of links in a very complex network of dynamic interrelationships. One of the necessary conditions of success in transfer programmes is that they reflect the structure of the total system of interrelationships instead of reflecting only certain portions of it in a haphazard fashion. Transfer programmes must therefore be approached by way of a carefully sequenced development of interrelated capabilities and supportive services.[65]

6. Large-scale technology transfer programmes are essentially long-term, difficult and costly because they imply the eventual creation of viable science and engineering units. They imply also the effective organization of training programmes related to specific technologies, the existence of secondary, technical and university education, an awareness of a country's links with the world technology market and judgements about the range of choice open to it on particular items.

7. In situations where the levels of expertise and information are low, the suppliers of marine technology are able to dictate terms and restrictive conditions which maximize profits earned on equity as well as on the sale of machinery, equipment, spare parts, and technical services.

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62 A/CONF.62/C.3/L.3 (mimeographed).

63 Information on these topics can be found in the following reports of the Secretary-General, entitled: "Economic significance, in terms of sea-bed mineral resources, of the various limits proposed for national jurisdiction" (A/AC.138/87): "Mineral resources of the sea" (E/4973 and Corr.1); and "Uses of the sea" (E/5120 and Corr.1).

64 J. Liston and L. Smith, *Fishing and the Fishing Industry–An Account with Comments on Overseas Technology Transfer,* prepared for the M.I.T. Sea Grant Study on International Marine Technology Transfer, June 1974, p. 81.

65 Chandler Morse, *Proposal for a Grant to Design a Long-term Program for the Transfer of Marine Technical Capabilities of the Less Industrialized Countries,* Ocean Policy Committee, National Academy of Sciences, September 1974, Mimeographed. See also Liston and Smith, op. cit., p. 60. "Transfer is successful only if it does two things. One is to create a structure, an indigenous organic system of interdependent decision-making units and operating components. At one level this system must comprise a set of vertically related institutions extending from pure science through applied research to production; at another level the training, career opportunities, financing, marketing and especially the localized production of instruments, machines and equipment. The second thing transfer must do is to initiate a dynamic process whereby the foregoing system components expand, proliferate and change in response to emergent needs and become increasingly independent of external influences, expertise and aid."

It is difficult for the recipient to know how much should be paid for the information unless he already knows what it is. In any event, information of new production technologies is not systematically available in developing countries.[66]

8. Sophisticated marine activities requiring considerable investment in capital, equipment and machinery may be undertaken through direct foreign investment, outright purchase of foreign hardware, through joint ventures or licensing contracts. In any case, education and training programmes would have to be established.

9. Technology is generally bought and sold in the world market in the form of information (e.g. designs), capital goods (e.g., equipment and machinery), or skilled manpower, and such components are generally subject to proprietary rights and are sold under restrictive conditions. The more modern and sophisticated the technology—as is the case with much marine technology—the more likely it is that the devices and processes are patented by individuals or corporations which are often multinational in scope. There is a high chance therefore that certain technological components will have to be obtained by means of foreign investment or co-operative ventures. On the other hand, if the recipient has partial familiarity with the specific technology required and has the technical and industrial capability to apply it, the development can often be promoted by using some hired expertise or purchasing or leasing some equipment from abroad.

10. Many projects are carried out through various forms of co-operative ventures in which the technology supplier and the recipient participate in varying degrees in the provision of skills, machinery, capital and in management control. Often, some of the elements are acquired as a package and others individually from the sources of supply. Thus, in a project for coastal area development involving construction of offshore terminals, a consultant agent from country "A" may be contracted to supply as a package the critical information on bottom topography, conditions of wind, waves, tides and subsurface currents of the coast, whereas an engineering firm from country "B" may be engaged to design and construct the terminals using mostly local manpower and materials. At the same time, the project may use United Nations technical assistance for the training of management personnel. In any civil engineering contract such as the example above, and in many other situations, it would be common practice for the country concerned to appoint a third party (e.g. an overseas consultant) to act on its behalf in managing and overseeing the contract. This again provides some measure of protection to a country not able to make its own technological assessments.

11. Both the direct and the indirect costs of large-scale transfer and transfer programmes are high and this should be recognized even before planning has begun. The direct costs of transfer include payments for the right to use patents, licences, process know-how and trademarks, and technical services at all levels from the pre-investment phase to full operation.[67] There is a premium on finding labour-intensive technologies for application in developing countries and this should be taken into account as one of the real social costs to be incurred by the recipient.[68] However, the terms of the contract made in the open market do not allow the recipient country much latitude in meeting this need. Usually, licensing agreements "... specify product characteristics that only the foreign investor's capital-intensive equipment can achieve" and alterations of trademarked goods are often forbidden.[69]

12. The indirect costs of transfer are also quite significant. Though these are difficult to estimate, they would have to include payments through: *(a)* overpricing of imports of intermediate products and equipment; *(b)* profits of capitalization of know-how; *(c)* a portion of the repatriated profits of wholly-owned subsidiaries of joint ventures; and *(d)* the price mark-up of technology included in the cost of imported capital goods and equipment.[70]

13. Compilation and dissemination of information is a primary function for the transfer of appropriate technology. But an information flow is not created automatically; rather, it has to be promoted through the efforts of national and/or international agencies.

14. In many countries, information has already been compiled and is available in national and international data centres. Access to this stock of compiled data, which is available at low cost, would obviate the need for expensive information inventories carried out by the recipient or the donor.

15. Educational programmes instituted in recipient universities or incorporated into the actual marine activity involved may assist the recipient country to develop the institutional and social flexibility and adaptability that would facilitate the generation of "local" technology over a, historically speaking, compressed time period.

1. *General approach to programme design*

16. It should always be emphasized that transferring technology means transferring not only hardware, but also operating and maintenance procedures, operating and maintenance skills, and management capacity. Otherwise the transfer will merely be a temporary graft and will not survive the programme.

17. The question of designing a transfer programme must therefore be approached systematically with careful consideration given to local economic and socio-cultural conditions. This may require the financing of interdisciplinary teams of people with significant input by nationals of the recipient country at every stage of the process. Resources must be adequate, and the entire chain of tasks comprising the transfer process must be approached in carefully sequenced strategies of application.

> "... [A] total programme should be designed to proceed in short, achievable stages to an ultimate goal. Each stage should represent a clearcut gain and step forward. Long-term programmes which show benefits only after a lapse of several years are too easily dropped, changed, destroyed, or sidetracked by economic or political change in either the recipient or donor countries. Large programmes should be built on a series of small projects protecting from total failure by their number and limited

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66 Surendra Patel, "Technological Dependence of Developing Countries: A Survey of Issues and Lines of Action", in John Gamble and Giulio Pontecorvo, editors; *Law of the Sea: The Emerging Régime of the Oceans*, Cambridge, Massachusetts, Ballinger Publishing Co., 1973, pp. 58 and 59. See also the list provided by Charles Weiss, "Technology Transfer and the Oceans", *Ibid.*, pp. 82 and 83; and Rutherford M. Poats, *Technology for Developing Nations*, Washington, D.C., The Brookings Institution, 1972, pp. 62 and 65.

67 Surendra Patel, op. cit., p. 63.

68 Rutherford M. Poats, op. cit., p. 58.

69 *Ibid., p. 59.*

70 Surendra Patel, op. cit., p. 64.

objectives and providing a number of alternative pathways to the ultimate goal, however that is defined. This is not intended to be an encomium in praise of short-term projects *per se.* Effective technology transfer requires a long-term commitment and sustained effort on the part of both donor and recipient. The suggestion is that this can better be done through integration of a series of small-scale projects than by attempting to develop enormous multinational efforts."[71]

2. *Regional approach*

18. In the law of the sea Conference much mention has been made of regional co-operation for technology transfer, on the assumption that regional co-operation minimizes the costs and maximizes the benefits for all participating countries. However, in many cases cost and benefits are not proportionately distributed. In many instances where a regional organization is a relatively effective continuing operation, the reason is that one member chooses to bear a disproportionate share of the cost even though others share in the benefits. This often happens on issues involving national security. Where organizational responsibilities appertain to economics or science and technology, this disproportionate cost sharing is much less likely and members tend to demand that there be little or no disparity between the apportionment of costs and the distribution of benefits.[72]

19. In cases where regional organizations oriented to economic, scientific and technical activities are relatively effective in performance the reasons for this have usually been: *(a)* either the "good" produced has been indivisible and of high value so that its attainment would have been impossible without effective collaboration (e.g., longer range and more accurate weather forecasts); or *(b)* although divisible the "good" produced was still greater than the perceived sum of the separate contributions (e.g., nuclear research in the European Centre for Nuclear Research (CERN), but there may be real cost limits to continuing co-operation in these instances); or *(c)* the primary source of contributions was external to the organizational members so that the question of the ratio of benefits to individual costs need never arise, for example, the International Maize and Wheat Improvement Centre and the International Rice Research Institute.

20. It is clear therefore that regional co-operation for the transfer of marine technology will not be a panacea. There will be limits to the utilization of this mechanism flowing from the problem of who will pay the costs for what kind of activity. At the same time the regional alternative should be carefully examined every time a new transfer programme is contemplated to see whether in that case the mechanism is likely to work.

II. A description of some marine activities

1. *Offshore oil and gas*

21. The production of petroleum and natural gas from offshore sources is one of the most complex and capital intensive marine industries. The high costs and risks associated with marine hydrocarbon exploitation have tended to restrict participation to large entreprises or corporations, many of which are multinational in their operations. The extent of vertical integration of the offshore oil and gas industry varies considerably. Some of the major multinational corporations engage in all operational phases, from the exploration stage to transportation refining and marketing. On the other hand, many enterprises utilize the services of firms specializing in discreet phases of offshore activity such as surveying, exploratory drilling, offshore facilities maintenance, etc.

(a) *Geological and geophysical surveying*

22. Remarkable technological advances in instrumentation for offshore surveying have occurred during the last two decades. Improvements in collection and data processing (gravity, magnetic field, and seismic reflection) and in position fixing techniques for survey vessels are particularly important. However, location and evaluation of marine hydrocarbon resources remain a costly and uncertain exercise; positive discovery and evaluation can only be accomplished by exploratory drilling.

23. Exploratory drilling is relatively expensive (compared to surveying), and prudent selection of promising sites depends upon information from geological and geophysical surveying. The location of the most promising structures in appropriate strata is the objective of offshore surveying.[73]

24. The main scientific techniques involve sensitive measurement of spatial variation of the earth's magnetic and gravity fields which can be interpreted to represent the different character of thick sedimentary basins from other continental or oceanic geological conditions. The most useful technique currently in use is the seismic reflection profiling system. This system utilizes an intense source of energy that produces sound waves which can penetrate the sea bottom to a depth of several kilometres. Measurements of the time of arrival of echoes from successively deeper layers of strata are made from hydrophones (underwater microphones). These measurements can be analysed by very sophisticated mathematical techniques to infer the location of geological structures.

25. Petroleum exploration firms utilize equipment that operates on the same principles as the instruments used by geologists and oceanographers to study the general geological structures and processes of the continental margins. However, the instruments used for direct petroleum exploration are exceedingly more refined and sophisticated in order to provide considerably more detailed data about subsurface geological structure on a scale as fine as several kilometres in dimension and depth below the surface. Geophysical data collection services have evolved into a separate industry and raw or analysed data can be obtained for many areas of the world for a fixed price. Such data may already have been collected and deposited in private industrial "libraries" or the exploration firms will undertake surveys at the specifications of the data buyer.

26. Some 450,000 lineal miles of continental margin geology have been surveyed around the world and are

71 Liston and Smith, op. cit., p. 59.

72 This is a deliberate simplification of a well-developed theory. Those interested in the original should see: Mancur Olson, *The Logic of Collective Action,* Cambridge, Harvard University Press, 3rd Printing, 1973; and Mancur Olson and Richard Zeckhauser, "An Economic Theory of Alliances", *Review of Economics and Statistics,* vol. XLVIII, August 1966, pp. 266-279. For an application to international organizations, see: John Ruggie, "Collective Goods and Future International Collaboration", in *American Political Science Review,* vol. LXVI, No. 3, September 1972, pp. 874-893.

73 The importance of these data for decision-making by the public sector is demonstrated by a recent directive of the United States Department of the Interior which requires that, all (outer continental shelf) geological and geophysical information not yet interpreted, that is corrected data in analogue and digital form, be submitted at no charge to the Department.

available for purchase. Typically, the collection of seismic reflection profiling measurements costs a minimum of approximately $US 100 per mile of survey strip travel, and analytical costs for geological interpretations cost an additional $US 30-50 per mile.

27. This (or even more intensely surveyed) geological information is then utilized to identify sites where the geologic formations show the highest probability of oil and gas accumulation.

(b) *Exploratory drilling*

28. Selection of exploratory drilling sites is based upon various criteria which include depth of water and depth of the structure within the promising sedimentary strata. Exploratory drilling at sea utilizes essentially the same kinds of drilling techniques developed for drilling of land. The equipment is mounted on fixed or mobile platforms (drilling ships, semi-submersibles, or jack-up rigs), and the time period required for drilling a single exploratory hole will usually be limited to several weeks (once the platform is at the site).

29. Obviously not all the exploratory wells discover economically exploitable concentrations of oil and gas. The investments for exploratory drilling range from hundreds of thousands to several million dollars (U.S.) per hole (depending upon depth of water and other factors).

(c) *Production drilling, completion and maintenance*

30. The discovery of concentrations of oil and gas by exploratory drilling will typically culminate several years of exploratory effort. Once the production decision has been made, at least several additional years would usually be required to produce oil and gas in commercial quantities.

31. Production drilling is normally accomplished from fixed or "jack-up" platforms, and a large number of wells can be drilled from the single platform by means of slant drilling techniques (12-24 wells per platform are not uncommon). In 1972, an 18-well drilling platform in 250 feet of water represented an installation cost of approximately $3 million (U.S.). "Completion" refers to the installation of all of the mechanical systems (valves, pipes, gauges, controls, etc.) which are necessary to produce oil and gas from offshore wells. The expenses of drilling and completion from the sea surface escalate significantly as the depth of water increases. It has been estimated that the world-wide offshore drilling and completion costs (well depth 12,000 feet), average approximately $2 million (U.S.) per well in water 500 feet in depth. The technology for subsea completions (using manned and unmanned submersible vehicles) is evolving rapidly, and it is expected that its costs may not be so closely associated with water depth as is the case for fixed platform completion systems.

32. After a well has entered production, periodic maintenance and "workover" is necessary to sustain downhole flow rates and a variety of sophisticated techniques is available for this purpose. Furthermore, injection of water or gas into oil-bearing strata can substantially increase the ultimate quantity of recoverable oil.

(d) *Storage and transfer*

33. Depending upon the depth of water and distance from shore, oil and gas will either be transported ashore by submarine pipelines, or will be stored and ferried by vessels or barges. Most offshore wells in production utilize pipelines for transportation, but as offshore operations are transferred to deeper water farther from shore, large storage systems become economical. The technology for the construction and placement of large storage tanks has already been tested by actual use. The average costs for submarine pipelaying range from $300,000 to $600,000 per mile, depending upon the pipe diameter and water depth. The costs for large offshore storage tanks may range from $15 to $30 per barrel of stored oil.

2. *Sea-bed mining and dredging*

(a) *Dredging and shallow water mining*

34. The technology for dredging has mainly developed in response to requirements for channel excavation and maintenance in nearshore areas for navigational purposes. In localities suffering from shoreline instability and erosion, the production of sedimentary material by dredging the adjacent sea-bed has been shown to be successful. In fact, as the value of shoreline space in industrial or tourist areas becomes increasingly scarce, the extension of land area by filling with dredged sediment may become economically attractive.

35. Surficial mining in shallow water utilizes dredging technology to obtain such minerals as gold, tin sands, iron sands, heavy minerals (titanium), and calcium carbonate (mollusc shells) as well as sand gravel. The technological principles of dredging are comparatively simple and involve sea-bed excavation by mechanical digging or suction with equipment mounted on a barge or vessel.

36. The wireline method utilizes a "drag bucket" or "clamshell dredge" to scoop sea-bed material and is capable of operating in relatively rough wave conditions. The continuous bucket ladder system has a great digging capacity and the hydraulic (suction) dredge with a cutting head has a high production capacity. However, both systems are restricted to sheltered sea conditions.

37. The capital investment for dredging systems is generally less than $5 million (U.S.) per system. Unit costs of production are highly variable and depend upon the hardness of the sea bottom and the prevailing sea surface conditions (wind and waves). The unit value of dredged mineral ores is also quite variable: the concentration of the mineral in the sediment, the spatial extent of the resource, and the depth of the water are critical factors.

38. Shallow water dredging technology is not as capital intensive as other marine technologies, and the unit value of dredged mineral bearing sediments may be economically attractive in some cases. The distribution and ocurrence of economic concentrations of specific minerals in shallow water are poorly known, and present evidence suggests that deposits may be quite local and limited in extent (i.e., placer deposits adjacent to river mouths). Exploration methods for broad surveys are generally limited, and discrete sampling programmes (by drilling, coring, or scooping) are expensive. Processing techniques for marine ores may be different and perhaps more costly than those for terrestrial ores. In the case of bulk minerals with low unit value (i.e., sand and gravel), the distance of the dredging site from the point of consumption is very significant and transportation costs may be prohibitive.

(b) *Deep sea-bed mining*

39. In contrast to shallow water mining which employs existing technology for dredging, mining operations on the deep sea-bed will require large scale and capital intensive technological innovations. Technology for extended activity at depths greater than 5,000 metres is still under development.

40. Extensive surveys employing underwater photography and television and direct bottom sampling by dredges and corers have verified the existence of vast quantities of manganese nodules and metal-enriched muds. Although the concentrations of valuable minerals in certain marine ores may be higher than in terrestrial types, the costs of mining and processing these ores in commercial quantities remain problematic.[74]

3. *Offshore structures, cables and pipelines*

41. The future of artificial offshore islands (floating or filled) is most promising in areas where land costs are exceptionally high, because of residential and commercial use, industrial development, or tourist activity. The potential uses of artificial islands are nearly as diverse as those for coastal land. In addition, the comparative availability of vigorous air and water circulation offshore may provide opportunities for harmless dissipation of effluents and heat associated with many industrial operations.

42. Using existing technology for dredging, filling, and wave protection, the construction cost per square metre of artificial island surface decreases inversely to the size of the planned island. Multipurpose islands for power generation, petroleum handling, waste processing and desalination have been proposed for the North Sea. Offshore airports may become economic in densely settled coastal areas. Technologically complex floating nuclear power plants, and residential/recreational structures are planned or under construction.

43. Submarine cables have been utilized as a practical alternative for energy transmission over modest distances (less than 100 kilometres). Undersea cables for communication continue to be vital links within regional and global networks. It has been estimated that laying of submarine cables in the deep sea costs approximately $10,000 per mile, but the cable technology has advanced so that present cables have the capacity to offer over 800 simultaneous circuits, with the possibility of up to 3,500 circuits in the foreseeable future.

44. Offshore pipelines for petroleum, chemicals, or slurried ores afford the opportunity to avoid sometimes hazardous surface transportation (lightering) from offshore terminals. As tankers and ore carriers continue to increase in size and draft (depth), offshore transfer facilities in many coastal areas become more necessary. Offshore storage tanks have also been developed to contain oil as an intermediate stage in the transfer process. The economic feasibility of offshore terminals and pipelines is strongly dependent upon very high volumes of cargo transfer and such installations are probably not appropriate except for major oil or ore exporting or importing countries.

4. *Submersibles and undersea habitats*

45. Visible light and radio waves are attenuated very rapidly in sea water—only sound waves travel any significant distance; saline waters are corrosive to most materials; except in the shallowest areas, sea water is very cold; ambient pressure increases greatly with submergence from the surface. These are some of the problems limiting human activity under water.

46. In shallow water (down to 100 metres) self-contained diving equipment affords the greatest opportunity for diver freedom. A protective suit and breathing apparatus are comparatively compact and inexpensive. However, the dissolution of respiratory gases in the bloodstream (because of elevated pressure from submergence) increases the deeper the diver descends and the longer he remains there. Such dissolution of gases in the diver's bloodstream requires gradual decompression to avoid physiological damage from the formation of bubbles. The time necessary for diver decompression increases as the duration of descent is extended. After a certain period of submergence (approximately 24 hours) the time necessary for decompression does not increase significantly if the diver remains near the same operational depth. Saturation diving utilizes this phenomenon and undersea habitats (gas-filled vessels maintained at the pressure of the surrounding water) have been developed to allow divers to live and work in the sea without the need to surface frequently and undergo lengthy decompressions after each ascent.

47. Because of the physiological rigours and the practical depth limits to diving, manned and unmanned submersibles have been constructed for a variety of purposes. Manned submersibles protect human passengers from the tremendous external pressure and from low temperature in a "shirt-sleeves" environment.

48. Submersible systems vary in complexity and cost and require expensive maintenance and support from surface vessels, usually of quite specialized design. Even the most sophisticated submersibles offer limited outside visibility to the operators, and any work must be performed by articulated mechanical arms, clamps and other devices. Operating costs for the most modest manned submersible are at least several thousand dollars (U.S.) per day.

49. The special training of personnel and highly complex technologies required for underwater work have limited the use of submersibles and deep diving systems. At the present time, the prime industrial user is the offshore petroleum industry in connexion with drilling and maintenance of underwater equipment and pipelines. Submersibles have been used in marine research and exploration and for search and rescue work. It is expected that offshore oil and scientific research purposes will remain predominant in the foreseeable future.

50. The costs of developing and employing submersibles in very shallow water (less than 50 metres) are considerably less than for more complex and higher endurance models for deeper submergence. Shallow water submersibles have been utilized for aquaculture and the possibilities for tourist and recreational uses may be substantial.

5. *Extraction of dissolved chemicals from sea water*

51. The quantities of disolved minerals and chemicals in the ocean are immense; virtually every naturally occurring element can be found in the ocean. However, except for several major components of sea water, the concentration of all other chemicals is exceedingly low. Large quantities of sea water must be processed to recover comparatively minute amounts of desired chemicals. Extraction of a limited number of dissolved chemicals from sea water is technologically and economically feasible.

52. Solar evaporation of sea water in enclosed pools is a widespread and inexpensive technique that yields concentrated salt bitterns. In addition to the industrially important compound sodium chloride (common salt), bitterns contain lesser amounts of various salts which can be extracted by relatively simple processes utilizing appropriate chemical agents. Potassium chloride and potassium sulfate can be extracted for use as fertilizers. Magnesium

[74] For current information on technological developments and related costs for deep sea-bed mining, see A/CONF.62/25.

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and sodium salts (other than sodium chloride) can also be economically recovered from bitterns.

53. Metallic magnesium is currently extracted from sea water in substantial quantities by processing salt bitterns with calcium carbonate from sea shells and then reacting the material with electricity (electrolysis).

54. Bromine gas, an important component for the production of leaded gasoline, is recovered from the ocean by simple treatment with sulfuric acid and chlorine gas. The bulk of the world's requirements for bromine is produced from sea-water. Deuterium (heavy water) is obtainable from sea-water and is important in nuclear engineering applications. Compared to other sources, the natural concentration of uranium compounds in sea water is sufficiently great that the continuing demand for the material may allow economic recovery in the foreseeable future.

6. *Desalination of sea water*

55. Growth in world population and expansion of agricultural and industrial activity will certainly increase the need for fresh water. It has been estimated that world consumption of fresh water may double in a matter of two decades. Desalination has been proposed as a partial solution to increasing demands for fresh water. Recent technological developments in desalination processes have been incorporated and tested in numerous facilities around the world. Nearly all of the plants have been of comparatively small capacity (several million gallons of fresh water produced per day), and the construction of much larger systems has been held in abeyance because of the expected costs of desalination compared to other water sources or practices.

56. The need for fresh water in specialized applications in remote or arid coastal locations will continue despite the production cost of up to several dollars (U.S.) per thousand gallons (for smaller scale facilities). However, more general usage of desalinated sea water will be predicated on a delivery cost of approximately $0.30 (U.S.) per thousand gallons. Agricultural use of water may be limited to costs as low as $0.10 to $0.15 per thousand gallons.

57. The most efficient technology in current use produces desalinized sea water at costs of slightly less than $1 (U.S.) per thousand gallons. Four general types of processing have evolved: distillation; membrane action (reverse osmosis); crystallization (freezing); and chemical reaction (ion exchange). Of the four processes, distillation by the so-called "flash" or "multistage flash" systems appears to be the most practical from the viewpoint of production cost and quantities of sustained production.

58. The economic operation of all of the processes is constrained by several major factors: first, all of the systems require large quantities of energy (heat or electricity) and fuel costs are very significant; secondly, corrosion may limit sustained plant operation; thirdly, in the case of distillation, "scaling" (chemical deposits) in piping reduces the heat transfer properties and thereby increases fuel requirements.

59. Plans for very large flash distillation systems have emerged with estimated production costs of less than $0.40 (U.S.) per thousand gallons that are intended to profit from further technological innovation and economies of scale. Because the energy costs form such a substantial portion of operating expenses of desalination, multipurpose systems have been proposed in conjunction with industries that produce large quantities of heat as a waste produce (i.e., nuclear or fossil-fueled power generators). Reliable cost of information from large-scale desalination or multipurpose facilities must await more detailed investigations of pilot plan operations.

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The Global Environmental Monitoring System of the United Nations Environment Programme[75]

[Original: English]
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1. The Global Environmental Monitoring System (GEMS) project was established upon a decision of the Governing Council of UNEP at its first session held at Geneva from 12 to 22 June 1973. Following that decision, the Executive Director convened an International Meeting on Monitoring in February 1974 which outlined the objectives, principles, programmes, goals and general guidelines of GEMS (see Annex) and listed the environmental variables that it recommended should be monitored as a matter of priority.

2. At its second session, by decision 8 (II), the Governing Council decided, among other things, to consider as a matter of priority the report of the Intergovernmental Meeting on Monitoring that was held at Nairobi in February 1974 (UNEP/GC/24) and a report to be prepared by the Executive Director on the result of his studies and analyses of the report of the Inter-governmental Meeting and on the progress in the implementation of GEMS. The Executive Director is accordingly submitting its report to the Governing Council in document UNEP/GC/31/Add.2 under the title "The Global Enviornmental Monitoring System". The present document is largely based on that report and on other documents prepared for the Governing Council.

3. GEMS is a co-ordinated effort of Member States, United Nations agencies and UNEP to ensure that data on environmental variables (such as pollutant levels and the state of living resources) are collected in an orderly and adequate manner for the purpose of providing Governments with a quantitative picture of the state of the environment and of the natural and man-made global and regional trends undergone by critical environmental variables. It will thus provide one of the tools that decision-makers require at the national and at the international level. Because of its regional and global nature, the main concern of GEMS will be with programmes whose results may lead to concerted action by more than one country, or with those that can only yield results, even of local import, if more than one country is involved in them.

* Incorporating document A/CONF.62/C.3/L.23/Corr.1 of 20 March 1975.

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