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COMMITTEE ON THE PEACEFUL USES OF THE SEA-BED AND THE OCEAN FLOOR BEYOND THE LIMITS OF NATIONAL JURISDICTION

ADDITIONAL NOTES ON THE POSSIBLE ECONOMIC IMPLICATIONS OF MINERAL PRODUCTION FROM THE INTERNATIONAL SEA-BED AREA

Report of the Secretary-General

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PREFACE

1. When considering the economic implications of international sea-bed resource use, during the summer session of 1971, the Committee on the Peaceful Uses of the Sea-bed and the Ocean Floor beyond the Limits of National Jurisdiction had before it the report of the Secretary-General entitled "Possible impact of sea-bed mineral production in the area beyond national jurisdiction on world markets, with special reference to the problems of developing countries: a preliminary assessment" (A/AC.138/36). This report suggested that the rapid development of knowledge and technology in ocean mining required periodical reviews of the subject. Moreover, during the March session of 1972, some members of the Committee requested the Secretariat to review recent developments in ocean mining. In this connexion, it was suggested that the countries where testing of nodule mining systems might be at an advanced stage, submit data to the Secretariat before 30 April 1972, to facilitate the review of these developments.

2. This report is divided into four sections: (1) a brief description of developments in ocean mining; (2) additional considerations on possible economic implications of these developments; (3) a further elaboration of some concepts of sea-bed resource development that could be used to minimize the possible adverse effects of marine mining on world markets in general, and on the export earnings of developing countries in particular; and (4) some issues of international commodity policy. 1/ The emphasis of this report on ocean-floor mineral resources is on possible ways to promote their rational exploitation.

I. TRENDS IN SEA-BED RESOURCES DEVELOPMENT

3. Technological developments and exploratory activities in 1971 have increased optimism regarding prospects for marine mining. The highlights of these developments affecting the offshore petroleum industry and mining for hard minerals are discussed below.

A. Petroleum

4. In the offshore petroleum industry the current trend is a distinct move into deeper waters to find and produce the oil that geologists have predicted would be found there. Detailed seismic surveys are being conducted in 1,000 metres of water at several locations and there is preliminary seismic work at depths up to 2,000 metres. Designs have been completed for fixed production platforms in water 210 m. deep in the Santa Barbara Channel (on the West Coast of the United States). Progress has also been made on diverless subsea well completion systems usable with floating rigs while other platforms are planned for depths of 300 m. Several new and sophisticated semi-submersible drilling rigs and drill ships are under construction which will be able to operate in deeper and rougher waters than hitherto. These newer drilling rigs and ships may cost over $15 million per unit, while in one instance the estimated cost is in excess of $23 million. 2/

1/ Submitted to the Third United Nations Conference on Trade and Development (UNCTAD III), Santiago, Chile, 13 April 1972, as document TD/113/Supp.4.

2/ K. Edmiston, "What is new in deep ocean drilling", in Oceanology, January 1972, p. 28; and Ocean Industry, February 1972, p. 41.

5. Related developments include a hole re-entry system of high precision and reliability which has been successfully tested at a depth of 200 m. 3/ Continuous improvements in pipe laying techniques in rougher and deeper waters have been reported. Progress has also been made in the design of offshore storage tanks. These will in the future considerably improve the economics of oil production in deeper waters and at great distances from the coast by eliminating the need for costly pipelines from the producing fields to land storage tanks. 4/ Important developments are also taking place in undersea working techniques as diving procedures and ancillary equipment are improved and unmanned vehicles and remote control robot devices become operational. The steady progress in all areas of deep water petroleum technology - exploration, production, storage and transportation - indicates that eventually oil production may be feasible in the outer continental shelf and upper slope. 5/

B. Metal-bearing muds and manganese incrustations

6. Sampling carried out during a geophysical probe of the sea floor across the entire North Atlantic Ocean found heavy incrustations of manganese ore - containing nickel, copper and cobalt - on exposed rocks in regions where earth movements have caused fractures in the sea-bed. The data available have caused some speculation that these incrustations on the mid-ocean ridges may be thicker and more extensive than the manganese nodules discovered over wide areas of the ocean floor in recent years. 6/ At present there is no technology available that would allow economic mining of these manganese incrustations. It will be difficult to break these crusts free from their solid attachment to the sea-floor bedrock.

7. Exploratory and engineering tests are continuing on the Red Sea metal-bearing muds. Under the sponsorship of the Government of the Federal Republic of Germany, the vessel Valdivia conducted extensive prospecting of the Red Sea from March to July 1971. It discovered a deposit of copper-zinc ooze, at a depth of 2,200 metres. New technology will have to be developed to recover these muds from the sea-bed and to extract the metals contained therein. It is reported that the metal content

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3/ Ocean Industry, February 1972, pp. 31-33, "Hole Re-Entry System passes tests in 580 foot water".

4/ "Largest floating storage barge", Ocean Industry, November 1971, p. 25.

5/ As in the previous report (A/AC.138/36), the prospects for marine hydrocarbons are discussed on the basis of an assumed maximum depth at which submarine deposits may be found. It is generally held that such deposits are associated with thick sedimentary layers which occur for the most part in proximity to land masses, rather than far from shore in deep ocean basins. It should be noted, however, that hydrocarbon exploitation in the area beyond national jurisdiction must in any event be regarded as a real possibility in the future, although present data do not provide a basis for estimating what the economic effects of such exploitation might be.

6/ "Trans-Atlantic survey finds manganese", Oceanology, October 1971, pp. 22-23.

changes, but at a site in the central part of the Red Sea the ooze yielded an average content of 5 per cent for zinc and copper. The ooze is found in deposits 30 m. thick in average. About 30 tons of samples were collected for further tests. The firm Preussag A.G. was reported to be granted offshore mining rights for an area covering these deposits, by the Government of Sudan. 7/ Scientists suggest that metal-rich muds and hot brines like those found in the Red Sea might also be encountered in other rift locations on the ocean floor.

C. Manganese nodules

(a) Exploratory activities

8. Exploratory activities increased during 1971, both by scientific expeditions that publish the results of their work and by concerns whose findings are of a proprietary nature.

9. The Soviet Union and several Eastern European countries have set up an international centre designed to co-ordinate their efforts in marine exploration. According to some sources, during a conference in Riga in 1971, the USSR indicated that joint expeditions are being planned in the Atlantic, Indian and Pacific Oceans to select prospective sites for mineral exploitation. 8/

10. Nodule deposit explorations in the Pacific have been conducted by a large number of commercial enterprises from many industrial nations. The United States company, Deepsea Ventures, has been conducting deposit exploration surveys in an area south of Hawaii. Centre National pour l'Exploitation des Océans (CNEXO), the French oceanographic agency, working in association with Le Nickel, has conducted exploratory work about 200 miles east of Tahiti where nodules high in cobalt and nickel have been found. Metallgesellschaft A.G. of the Federal Republic of Germany has also been engaged in nodule surveys in the Pacific Ocean. Kennecott Corp. has developed its own sampling and exploration equipment and techniques, and on a number of cruises since 1967 has sampled over 3,000 manganese nodule sites. 9/ Several academic institutions in the United States such as Scripps in San Diego, Calif., Woods Hole, Mass., and Lamont-Doherty Observatory of Columbia University in New York, have also conducted extensive nodule deposit surveys.

(b) Mining systems

(i) Airlift and hydraulic

11. Further developmental work is continuing in the air-lift system developed by Deepsea Ventures. Several enterprises in Japan, North America and Western Europe are at different stages of design and testing of nodule mining systems. The

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7/ "Red Sea Exploration", in Mining Magazine, Nov. 1971, pp. 401-403.

8/ "Soviet block plans big sea-bed study", The New York Times, 24 April 1971.

9/ T. N. Walthier, "The current status of ocean mining", in Mining Engineering, October 1971, pp. 51-53.

Demag Company of West Germany has designed a hydraulic mining system which could operate at water depths up to 15,000 feet. This system would have a pumping station, engine room and primary nodule processing facilities installed in a 22-metre long submerged compartment. The nodules would be collected from the sea floor by special equipment mounted on crawlers and pumped up to an intermediary submerged processing station from where they would be lifted to the mining ship. 10/

12. The Hughes Tool Company has made a major commitment of perhaps over $50 million to the development of a manganese nodule mining system. Global Marine of Los Angeles is the general contractor for the Hughes Tool Co. project, which now has two mining vessels under construction. A 600-foot, 35,000 ton vessel, estimated to cost about $40 million, is being constructed at the Sun Shipping Yard in Pennsylvania. A second vessel (320' x 107') is being built at the National Steel and Ship Building Yard in San Diego, California, according to a design of Lockheed Missiles and Space Company. The advanced pumping technology developed by the Hughes Tool Company and the odd size of this second vessel reportedly may indicate that mining would be carried out by air-lift hydraulic means with the pumping station submerged 250 feet or more below sea level.

(ii) The continuous line bucket (CLB) system

13. This system was conceived and developed by Commander Yoshio Masuda of Japan. It consists of a continuous loop of cable to which is attached a series of dredge buckets. The loop of cable is sufficiently long that it is able to reach from a surface vessel and down to the ocean floor. It was tested during the summer of 1970 at several depths (up to 3,500 m.) in locations near Tahiti where nodule deposits have been found.

14. The production capacity of the CLB system is a function of the size of the buckets, the spacing of the buckets on the dredge cable, the velocity at which the cable loop is operated and the filling efficiency of the buckets. The filling efficiency of the buckets depends on their design and on operational conditions, namely, the lateral velocity of the surface ship in relation to the vertical velocity of the cable and the length of line with attached buckets which is allowed to drag on the ocean floor. The appropriate operational practice (i.e. synchronization of cable speed, lateral ship velocity and bucket drag on the sea-floor), is intended to prevent the buckets from passing continuously over the same area of the sea-floor. The results of the 1970 tests seem to indicate that filling efficiency could be maintained at over 50 per cent of bucket capacity with appropriate operational practice. 11/

10/ "Mining system will process ore in under-water station", Ocean Industry, October 1971, p. 18.

11/ John L. Mero, "Will ocean mining prove commercial?", in Offshore Technology, April 1971, p. 131. See also "The Future Promise of Mining in the Ocean", in Canadian Mining and Metallurgical Bulletin, April 1972, pp. 21-27, and "Continuous Bucket-Line Dredging at 12,000 feet", in Offshore Technology Conference preprint (prepared for the Third Annual Offshore Technology Conference, Houston, Texas, 19-21 April 1971.

15. The basic limiting factors to production capacity in the system are: power, bucket size and cable strength. The test to be conducted during the summer of 1972 will use 16,000 m. of 120 mm. diameter polypropylene rope with a 150-ton breaking strength. The two bucket sizes to be tested will have a 0.5 m^3 and 0.3 m^3 capacity, 12/ and will be attached to the cable at 25 to 50 metre intervals. About 900 kw of power will be available for traction of the CLB system in the vessel to be used for the tests this summer. The power available and the size of buckets will limit maximum production of this CLB system to 650 tons of nodules per day. By increasing the power rating of the traction driving motors and increasing the bucket dimensions, production capacity could be increased, in principle, to about 3,800 tons of nodules per day, at which point the breaking strength of the cable (150 tons) would be approached. Cables of braided polypropylene with rated breaking strength of 500 tons are already being manufactured in Japan. By using such a cable and more powerful motors, the production capacity of the system might be increased to about 7,600 tons of nodules per day. 13/

16. The CLB test this summer will be conducted under the general direction of Mr. Masuda aided by Dr. Mero and it will be financed by a consortium of over 20 firms. This consortium was established only for financing and supervising the test, after which each participating company will be in a position to decide whether or not to lease the use of the system from the patent owner, Mr. Masuda. The main objectives of the test are:

(1) To test the CLB at sea in varying operating conditions on actual deposits of nodules that would be considered economic to mine;

(2) To obtain engineering data concerning all operating aspects of this system;

(3) To achieve routine production operation for a period of at least 10 days;

(4) To determine possible tendencies for equipment malfunction and resulting downtime;

(5) To secure about 3,000 tons of nodules from at least three separate deposits, for distribution to participants in the test; and

(6) To prepare complete engineering reports indicating the optimum design of the system and its operation, including all engineering and cost data generated in the test.

12/ The bulk density of nodules is about 1,000 kg. per m^3, therefore the buckets to be tested, if filled at 50 per cent capacity will bring up about 250 kg. and 150 kg. of nodules each.

13/ Source: Ocean Resources, Inc., La Jolla, Calif.

(c) Metallurgical processing

17. For some time, the processing of nodules was thought to be an even more difficult problem to solve than the recovery of nodules from the ocean floor. In the last two years, however, several announcements have been made indicating that a number of different procedures for the economic extraction of metals from nodules have been successfully tested.

18. Deepsea Ventures is continuing developmental work on a hydrometallurgical process which was tested in 1971 in a 1-ton/day pilot plant. The company is reported to be preparing additional process tests on a 10-ton/day pilot plant. The process starts with the crushing and drying of the nodules to expose a larger surface area and to promote reactiveness. The ground nodules are then reacted with hydrogen chloride in furnaces, and the soluble metal chlorides are subsequently leached with water. The leach liquor is then processed with solvent extraction liquids to separate copper, cobalt and nickel, which are recovered by electrolytic precipitation. The remaining manganese chloride solution is stripped of residual metals such as cadmium, zinc and chromium, and then converted into manganese metal. 14/ High rates of metal recovery - over 95 per cent - are claimed for this process.

19. The United States Bureau of Mines Research Station at Salt Lake City has announced the successful experimental processing of nodules by an acid and ammonia leaching system. High recoveries of all metals in the nodules were achieved in this rather conventional approach to nodule processing. The Kennecott Copper Co. after some 10 years of research on all aspects of nodule mining and processing indicated the development of a pyrometallurgical process technique. Though pyrometallurgical processes generally involve rather high investment and operational costs, recovery of nickel, cobalt and copper in the Kennecott process is reported to be above 90 per cent.

20. Experimental work is under way at the University of California, Berkeley, to develop a technique of differential leaching of metals from nodules. This oxide heap leaching process permits the separation of nickel, copper and cobalt without getting either manganese or iron into the solution. This process would thus permit nodule processing with rather low initial plant capital and operating costs. To date these experiments have permitted the recovery of only 60 per cent to 80 per cent of the metal content in the nodules, but it is hoped that further development might increase processing efficiency.

(d) Time horizon for nodule exploitability

21. The nature of manganese nodule exploitation, involving new technology for both the mining and the processing stages, makes it difficult to predict when the first venture will become operational. Some delegates in the Sea-Bed Committee have suggested that commercial recovery might become possible by the end of this decade. Industrial circles tend to be more optimistic. Deepsea Ventures maintains

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14/ A. B. Caldwell, "Deepsea Ventures Readying its Attack on Pacific Nodules", in Mining Engineering, October 1971, pp. 54-55.

that by 1976 they could be mining and processing nodules, if the question of exclusive rights to sites on the ocean floor can be satisfactorily resolved. 15/ The promoters of the continuous line bucket system have indicated that commercial exploitation of nodules could commence before 1975. Furthermore, the large vessel and the mining system under construction for Hughes Tool Co. are expected to become operational in 1973, thus raising the possibility that they may have the capability for commercial production in late 1973 or 1974.

II. ECONOMIC IMPLICATIONS OF SEA-BED MINERAL PRODUCTION

22. The rapid progress in sea-bed mining technology and metallurgical processing in recent years indicates the possibility of substantial mineral production from the deep sea-bed. The question now is how soon will this take place. Estimates of the long-run economic implications of sea-bed mineral production are difficult, in view of the rapid development of marine mining technology, which may in due course permit production of nickel, copper, cobalt and possibly manganese, not only from nodules, but also from metal-bearing muds. In the more distant future, when the necessary technology is developed, production may even be possible from manganese incrustations on oceanic ridges which also contain nickel, copper and other metals.

23. The amount of research and development work being devoted to the mining of manganese nodules makes it probable that metal extraction from nodules will reach the commercial stage before production from metal-bearing muds or manganese incrustations. Indeed, it is quite possible that commercial manganese nodule exploitation could start within five years. In view of the uncertainties regarding future technological developments for the exploitation of metal-bearing muds and manganese incrustations, only the processing of nodules is considered in the following assessment of the economic implications of sea-bed mineral production.

24. Developments reported since the preparation of the previous study by the Secretary-General on the possible economic impact of sea-bed mineral production (A/AC.138/36) do not seem to have affected the preliminary conclusions suggested in that report. Additional information now available, however, has brought some points into better focus. Metal recovery rates will depend on the site mined

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15/ The American Mining Congress drafted some proposed deep sea-bed legislation, which was introduced in the United States Senate as Bill S.2801 by Senators Metcalf, Allott, Bellmon, Jackson and Stevens. The Bill was referred to the Committees on Interior and Insular Affairs and Foreign Relations jointly. Similar proposed legislation has also been introduced in the United States House of Representatives. In a statement before Sub-Committee I of the Sea-Bed Committee on 14 March 1972, Dr. Vincent E. McKelvey indicated that the Executive Branch of the United States Government had not taken a position on this Bill.

as well as on the metallurgical processing method adopted. Despite the uncertainties inherent in estimates based on new technology, the figures suggested in the previous report (A/AC.138/36) for hypothetical production from a single mining operation (i.e. 1 million tons of dry nodules per year) are still thought to be valid. However, on the basis of several known samples of rich nodules, it is likely that nickel production could be at least 15 per cent greater, and perhaps as much as 50 per cent greater, than copper output. 16/ The possible impact of nodule mining on mineral markets is tentatively estimated in the following paragraphs.

A. Cobalt

25. The probable high volume of cobalt production from nodules in relation to world demand for this metal suggests that this market might be the first to be affected by sea-bed production. A single mining operation might be able to supply about 8 per cent of the world cobalt requirements by 1980. 17/ Two factors, however, would tend to moderate the impact of the increased supply on the market. The first is the possibility that demand for cobalt might expand more rapidly if prices were lower. In the past, elasticity of demand for cobalt has been rather low; however, prices have seldom remained at comparatively low levels for sufficiently long periods of time to encourage its use in new applications. A large steady supply from the nodule industry could be expected to change this situation. The second factor comes from the nature of the existing market: a single major producer in a developing country is in a position to restrict supply in response to a decline in prices. This behaviour of the price leader might change if cobalt production from nodules became the dominant source of the metal.

26. The impact of sea-bed supply on the cobalt market could be quite dramatic, if the high Co content nodules of the mid-Pacific rise were mined. 18/ In this area, west of Hawaii, a single mining operation dredging 1 million tons of nodules per year with 2 per cent Co content would be able to supply about 19,200 tons of cobalt. This is equivalent to almost the total output from land in 1969, and would amount to half of the possible 1980 world demand for cobalt (based on extrapolation of present uses for this metal).

27. In short, it is expected that cobalt production from nodules will tend to reduce prices, although it is impossible at this time to say how soon, and by how much, prices may drop. There is, however, a possible floor to the decrease in

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16/ Annual production from one 1-million ton/year operation might be approximately 16,000 tons of nickel; 13,000 tons of copper; 2,800 tons of cobalt, and 270,000 tons of manganese, if this mineral were also recovered.

17/ A/AC.138/36, p. 56.

18/ Mineral Resources of the Sea, (United Nations publication, Sales No.: E.70.II.B.4), p. 14.

cobalt price, namely the price level of nickel. 19/ Since cobalt could be a substitute for nickel in several uses, it is quite possible that if cobalt prices were to drop to the level of those of nickel, nodule processors might supply the two metals together rather than separate them.

B. Manganese

28. Manganese markets could also be affected by marine production, since demand is quite inelastic and no major new uses can be foreseen to absorb increased supplies of this mineral at lower prices. However, it is by no means certain that extraction of manganese will prove to be commercially attractive. Depending on the metallurgical process adopted the processing of nodules may yield (in addition to nickel, copper and cobalt): (1) a useless slag to be discharged; (2) a low-grade manganese ore equivalent (manganese oxide); (3) ferro-manganese; (4) pure manganese metal. It is yet too soon to speculate on the metallurgical process or processes which will be most economic in the future. It appears, however, that manganese recovery is likely to be the most expensive stage of nodule processing; most processes under consideration do not provide for the recovery of manganese. Preliminary cost estimates suggested for various methods of nodule processing seem to indicate that production of manganese oxide from nodules might not be competitive with land-based manganese ore at present prices (about $US 60 per ton of manganese in ore CIF to the United States East Coast or Gulf ports).

29. Although it is too soon to predict whether any recovery of manganese in the form of oxide will, in fact, be carried out, the prospects for doing so are not promising. But if the Mn-Fe content of the nodules cannot be sold, the processor will incur a certain cost in discarding the useless slag (from $1 to $5 per ton of nodules). Since the costs of mining, and that of recovering the other metals will have already been paid for, and considering the alternative cost of waste disposal, it is conceivable that some uses for the iron-manganese residue could be found if it were sold at a very low price.

30. It is conceivable that production of ferro-manganese and manganese metal from nodules might be commercially viable. The price of ferro-manganese 20/ in the United States is about $182 per ton and that of manganese metal (around $650 per ton) is more than ten times the price of manganese in ore form. This means that despite the rather high processing costs for manganese alone (perhaps ranging from $20 to over $100 per ton), nodule mining enterprises might find it attractive to produce ferro-manganese and manganese metal. However, present markets for these two commodities are quite limited, and additional supplies are bound, at least initially, to depress prices. As production of manganese metal

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19/ The price of cobalt at present is about $US 2.20 per pound and the price of nickel $US 1.30 per pound.

20/ Standard quality, 74-76 per cent Mn.

and ferro-manganese increases, the over-all structure of manganese markets might change. There could be an increase in the share of manganese utilized in the form of metal and ferro-manganese, at the expense of ore. What is important is that the three markets (ore, ferro-manganese and metal) are interrelated, and that irrespective of changes in the structure of supply, the aggregate demand for manganese in all forms is not likely to be much affected. It will probably remain essentially a function of steel output, which consumes about 94 per cent of total manganese production.

C. Nickel

31. Nickel recovery is expected to be the mainstay of the nodule industry, accounting for over 50 per cent of gross revenues. 21/ Demand for nickel is expected to grow fairly rapidly for the next two or three decades, even at the present rather high prices. The increase in demand could be even greater if nickel prices decline. In view of this highly dynamic outlook it does not appear probable that sea-bed mining would have serious adverse impact on nickel markets.

32. The favourable market during the second half of the 1960s, with its steadily rising prices, induced land-based producers to expand their capacity. If all the expansion plans reported in 1970 were to materialize, world nickel production capacity by 1975 would be increased by 88 per cent. 22/ Even accepting a relatively conservative view, production capacity would still increase from 650,000 tons per year in 1970 to about 1,050,000 tons per year by 1975. This would still be a considerable increase, amounting to a cumulative annual rate of 10 per cent.

21/ Any estimate of future revenues from nodule operations is faced with the difficulty of what prices to use, since these may be affected by marine production. Assuming that the first venture could sell its output at existing market prices, and that a manganese ore equivalent would be produced, the annual gross revenue from the sale of minerals could be estimated as follows:

Commodity	Annual production* in metric tons	Approx. market price (US $)	Annual gross revenue
Manganese ore	270,000	$50 per ton	$13,500,000
Nickel	16,000	$1.30 per pound	$45,750,000
Copper	13,000	$0.50 per pound	$14,300,000
Cobalt	2,800	$2.20 per pound	$13,550,000
		Total	$87,100,000

* See foot-note 13.

22/ E. Boudet, M. Janjou et C. Deschamps, "Perspective de développement de la production mondiale de nickel", in Annales des Mines, Mars 1971, pp. 23-42.

D. Copper

33. Of the four minerals concerned, production of copper from nodules is likely to have the least immediate impact. Firstly, the demand for copper is about 10 times larger than that for nickel; secondly, metal production from nodules will be approximately 4 tons of copper for each 5 tons of nickel, although as noted above, the ratio could be as large as 1 to 2; and thirdly, the economics of nodule mining is mainly dependent on nickel production. The effect of sea-bed mining on copper markets under present conditions would probably be equivalent to one tenth of the impact on nickel markets.

34. This situation would change, of course, if the demand for nickel were to increase at a much faster rate than the demand for copper. If, for instance, demand were to grow by 10 per cent a year for nickel and by 4 per cent for copper, at the end of three decades demand for copper would amount to about twice the volume of the demand for nickel. Under such conditions, the possibility of nodule mining affecting copper markets would increase appreciably. Of course, the materialization of such a hypothetical situation would imply a major change in the consumption patterns of the two metals, which in recent years have increased at approximately the same rates.

35. If it is assumed that the major increase in nickel supply would be derived from nodules (and reference has already been made to forecasts of increases in land-based production), the expansion required in the marine mining industry would be indeed gigantic. Taking the extreme example that total increase in demand for nickel from 1975 to 1990 (growing at 10 per cent a year) would be met from nodule mining, it would be necessary to have approximately 260 nodule mining ventures in operation by that time. It would also follow that to keep up with this 10 per cent annual growth of demand, by 1990 an additional 31 new manganese nodule ventures would have to become operational to meet the increase for that year alone. 23/

36. Although extreme, this example none the less serves to underline the many uncertainties inherent in forecasting the economic implications of future mineral production from the international sea-bed area, and points to the need for a continuous effort in planning and management.

III. PROMOTING THE RATIONAL DEVELOPMENT OF SEA-BED RESOURCES

37. Development of the resources of the international area poses novel challenges to the international community. Exploitation of sea-bed resources would substantially expand the world resource base at a time when considerable concern is being expressed in some quarters about the adequacy of world resources to

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23/ Based on the production of 1 million tons of dry nodules per year, with 1.5 per cent nickel content and a metal recovery factor of 96 per cent.

sustain increasing levels of production in the long run. On the other hand, it is quite possible that large-scale development of sea-bed resources would affect, to varying degrees, some traditional on-land producers. Moreover, the advanced technology needed to explore and exploit these resources is being developed by the most advanced industrial countries, and this raises the possibility of widening further the technological gap between industrial and developing countries.

38. As noted, the time horizons for development of these resources are still uncertain, although there are strong indications that nodule exploitation could commence within five years. Some effect from increased competition on manganese and cobalt markets could be felt as soon as such exploitation began. It is likely that the impact of large-scale nodule exploitation will be felt more strongly in the 1980s.

39. These considerations suggest the importance of early and careful study of what is entailed in rational development of the international area and its resources. It is evident, of course, that there are many ways of promoting such rational development, particularly in the light of the differing approaches made to the nature and powers of the types of international machinery that have been proposed or suggested. Similarly, it is also evident that much more information, and organization for retrieval of information, is necessary for such purposes. The following sections provide a brief review of some of the particular considerations that would need to be borne in mind in appraising what is the primary concern of the present report, namely, the economic implications of sea-bed resource development and the means of minimizing any adverse economic effects caused by the fluctuation of prices of raw materials as a result of this development. The following pages present some theoretical and tentative considerations on possible ways to promote the rational development of sea-bed resources and they deal with a very few of many alternative options.

A. Planning sea-bed resource development

(a) What could be planned

40. This report is primarily concerned with the economic implications of sea-bed resource development. However, the interest in promoting the rational utilization of sea-bed resources should not obscure a broader issue, namely, that the development of these resources may affect, or may be affected by, other uses of the ocean. For example, fishing, shipping, cable communication, and the use of the ocean as a dumping ground for wastes are all variables in the global picture of alternative and conflicting ocean uses. 24/ It can be expected that, with the

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24/ The Economic and Social Council has shown concern for this issue by requesting in its resolution 1537 (XLIX) a background study on traditional and foreseeable uses and conflicts in the use of the oceans. The report has been submitted to Member States for comments; the Secretary-General has requested suggestions on ways and means of strengthening international co-operation in marine affairs.

continuous development of marine activities, conflicts in the use of the ocean space and its resources will increase. In the light of the objectives laid down in the Declaration of principles contained in General Assembly resolution 2749 (XXV), the international community will have to face the problem of co-ordinated use of ocean space and its resources, in ways which would minimize conflicts and protect the marine environment.

(b) Data availability and planning

41. Increasingly detailed information will no doubt be required when proceeding to the stage of discussion at the Law of the Sea Conference on the various specific features of the international régime. Once the international machinery is established, it can be foreseen that one of its first tasks will be to organize the necessary information network to supply the data needed to orient the decision-making process.

42. Two lines of action are needed to create an efficient system of information: (1) access to existing data related to marine matters, and (2) filling up the gaps in the network. Several data banks already exist. What is needed now is not necessarily a centralized storage of all ocean-related data but an inventory of existing data banks with means for rapid access to their contents. 25/ Of particular importance for sea-bed resource management would be information on sea-bed geology, ocean bottom topography, ocean currents, and surface conditions.

43. Notwithstanding the recent increase in research activities, very large gaps in knowledge still exist. 26/ The most important information areas for sea-bed resource management are: (1) distribution of mineral resources on the ocean floor and in its subsoil with indication of their location and economic importance; (2) technological developments related to the exploration, exploitation and processing of sea-bed resources; and (3) environmental hazards resulting from marine mineral activities.

(c) The objectives to be sought

44. The objectives to be attained by an international régime in general are laid down in the Declaration of principles contained in General Assembly resolution 2749 (XXV). Based upon the decisions of the conference on the law of the sea on the nature of the régime and of the international machinery, the objectives to

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25/ A similar proposal has been put forward by the Preparatory Committee of the United Nations Conference on the Human Environment in calling for an information referral system.

26/ The international community is cognizant of these deficiencies, and is promoting several programmes of marine research, among which should be noted the Long-Term and Expanded Programme of Oceanographic Research (LEPOR).

be envisaged presumably would be those inferable from the Declaration as well as from proposals and suggestions made in the Committee and elsewhere. As far as the development of sea-bed resources is concerned these might perhaps be summed up as providing the following guidelines for planning:

(1) Encourage the use of the area and its resources in such a manner as to foster the healthy development of the world economy and balanced growth of international trade, and to minimize any adverse economic effects caused by the fluctuation of prices of raw materials resulting from such activities.

(2) Obtain the maximum net benefit for the world community, including financial benefits, which would be shared taking into consideration the special interests and needs of the developing countries, whether coastal or landlocked.

(3) Provide for the orderly, efficient, balanced development and use of living and non-living marine resources (conservation).

(4) Preserve the quality of the marine environment.

45. A central issue to which resolution 2750 A (XXV) was addressed is the possibility that the future production of marine minerals might cause considerable impact on the trend of market prices of these minerals. This concern was stressed in the Declaration of principles, which postulated that the development of the area and its resources should be carried out in such a manner as to "minimize any adverse economic effects caused by the fluctuation of prices of raw materials". This consideration deserves some further analysis.

46. In situations of price fluctuations somebody's loss is someone else's gain. If prices rise sharply due to temporary shortages, consumers are penalized but producers benefit from the situation. If, on the other hand, the short term demand-supply imbalance causes prices to drop, consumers benefit at the expense of producers. Though both cases have disruptive effects, it seems that one of the prime objectives in the development of marine mineral production will be to avoid adverse effects to traditional suppliers in developing countries. It is obvious that a decrease in raw material prices would adversely affect the economy of several developing countries exporting these minerals. It should also be remembered that a much larger number of developing countries are importers of these minerals (in raw material or processed form) and a drop in prices would be beneficial to them. However, the major beneficiaries of lowered prices would be developed countries since they are the main importers.

(d) Some special problems

47. Two technico-economic dimensions will influence the design of appropriate control mechanisms for sea-bed resource development. The first is the time horizon. The average gestation period of a marine mining venture might range from 6 to 10 years; negotiation of a site for exploitation; design and building of the marine mining system; and processing plant would all need to be complted before successful operations could begin. This means that the planning of marine resource

utilization, to be carried out by the international machinery will have to look at least one decade into the future. Even if considerable progress has been made in site evaluation and system design by the time the exploitation permit or contract is granted, it will take some two to four years before the output reaches the markets. But before the interested party makes the decision to go ahead with the venture, it will need to know the rules governing sea-bed mineral exploitation. The general legal arrangements affecting the parties involved in marine mining ventures will, of course, be defined by the international régime. Within this framework, any "fiscal" and regulatory measures to be determined by the machinery will require a considerable lead time.

48. The other technico-economic consideration is that the processing of some sea-bed minerals, such as manganese nodules, will yield simultaneously several metals in proportions quite disparate from world demand. For each ton of cobalt produced, approximately 97 tons of manganese, 5 tons of nickel and 4.9 tons of copper could also be recovered. On the other hand, present world demand in proportion to 1 ton of cobalt is of the order of 381 tons of manganese, 27 tons of nickel, 279 tons of copper. 27/ Therefore one nodule mining venture by 1980 could be capable of supplying about 7.9 per cent of the probable world demand for cobalt, 2 per cent of manganese, 1.3 per cent of nickel and only 0.13 per cent of copper. It is possible that eventually the processing plants might also be capable of recovering several other metals found in trace quantities in the nodules. At the present time it is impossible to provide any reasonable estimate of the likely volume of production of these trace metals and their possible impact on world markets.

(e) The equivalent fiscal charge principle

49. Theoretically, in the absence of any regulatory mechanisms, sea-bed resources would tend to be developed when, and as long as, the available marine mining technology would make these ventures economically competitive with land-based alternatives. However, the use of market indicators for "efficient" resource allocation presupposes that these indicators have not been distorted. The most obvious possibility of distortion would occur if major subsidies were granted for, or disincentives imposed on, sea-bed resource development as compared to traditional sources of mineral supply.

50. The application of the principle of equivalent fiscal and other regulatory measures for all sources of supply irrespective of origin, would encounter enormous difficulties, considering the existing differences in economic and social systems. Some countries, for instance, use the argument of infant industry to grant special incentives to new industries that they wish to promote. Others with very favourable competitive advantage derive a larger fiscal charge from similar industries. In some cases, strategic or protectionist considerations have induced the Government to grant outright subsidies for domestic production of some special minerals. These practices indicate that in reality the "fiscal charge" in

27/ Document A/AC.138/36.

land-based operations might range from a negative tax (subsidy) to a very steep charge of almost 50 per cent of the market value of some minerals. Given such a wide range of possibilities the "average fiscal charge" would be of very limited usefulness in establishing an "equivalent levy" for sea-bed mining operations. Therefore, the determination of an appropriate "fiscal" levy for resource exploitation in the international area would have to be a politico-economic decision taking into account: (1) the financial and technical situation of sea-bed mining operations; (2) the policy objective of generating maximum long-run financial benefits for the machinery and the international community; and (3) stabilization objectives for the minerals concerned.

B. One possible strategy to control the impact of sea-bed mining

51. The nature of the nodule industry with production of the four major metals in quantities quite different from the actual volumes of demand for these metals, will make the task of controlling the possible impact of sea-bed mining on world markets exceedingly complex. The control of possible adverse economic effects of sea-bed mineral production will have to be reconciled with the objectives of generating maximum revenues for the international machinery and actively promoting the expansion of the world resource base. Therefore, a rather sophisticated system might be required to strike an acceptable compromise among these conflicting goals. No one single policy instrument would be sufficient to produce all the desired results. Several control mechanisms would be required to provide the necessary flexibility for the machinery to respond to the problems encountered in each mineral market, without necessarily choking off development of the other minerals. A number of alternatives could possibly be devised to meet these needs; at this stage only one possible strategy is explored, in the remainder of this section, to illustrate the main factors that might be involved in exploitation of manganese nodules. It is hoped that this preliminary exercise will stimulate discussions of this issue. The Secretariat will examine, in future reports, other alternative approaches that may emerge in further consideration of this problem.

52. The strategy examined in this report would require the co-ordinated use of an exploitation policy with "fiscal" and compensatory action by the machinery. Commodity arrangements could also be envisaged to supplement these instruments. Each policy instrument in itself would provide limited results in relation to the several objectives pursued, but an appropriate combination of these policy tools might bring about the desired effect.

53. The exploitation policy would be designed to control the rhythm of production. It has been shown that nodule processing will affect each mineral market in substantially different ways. Manganese and cobalt markets could be affected by the very first large-scale nodule operation, nickel markets might only feel a substantial impact after the nodule industry expands considerably, and a serious impact on copper markets may only come much later when (and if) substantial changes in the nodule industry and in metal markets occur. Thus, whatever pace

of exploitation is decided upon, some mineral markets would be affected. Since copper is the most important mineral export of developing countries, 28/ the exploitation policy might have to be geared to prevent a major impact on this metal market.

54. The "fiscal" policy would have the primary objective of providing the maximum possible revenue for the machinery compatible with the creation of necessary prerequisites for the development of the nodule industry. At the same time the "take" of the authority could act as a built-in price stabilizer.

55. To the extent that the exploitation policy and the proposed levy per ton of mineral produced were unable to prevent some detrimental impact on the exports of some developing countries (perhaps for some manganese and cobalt producers), compensatory measures could be used. They would be in line with the provisions of paragraph 2 of General Assembly resolution 2750 A (XXV) calling for minimizing "any adverse effects caused by the fluctuation of prices of raw materials". Compensatory schemes could also be supplemented by commodity arrangements which might be negotiated for those minerals facing serious market fluctuations. 29/

56. A comprehensive policy would be directed in part to promoting a desirable measure of long-run equilibrium for the minerals to be produced from the sea-bed. The decisions on specific policy actions would require, therefore, the aid of long-term planning techniques. In essence, the guidelines for action might be derived from studies of market conditions based on five, ten and twenty years forecasts of demand and supply from traditional sources in conformity with several possible alternative volumes of sea-bed production for the various minerals.

(a) The exploitation policy

57. Once the long-term forecasts of demand-supply conditions are available, the machinery would be in a position to decide upon an appropriate exploitation policy. It must be noted that there are two different issues involved in any possible exploitation policy: (1) the method of allocation of production permits; and (2) the actual number and size of mining undertakings which would start operations each year. 30/

58. The manner in which exploitation of sea-bed resources is to be conducted will be defined by the régime. The Committee has under consideration several proposals regarding the possible granting of concessions of sea-bed resources to interested parties, or conversely, reserving the exploitation of resources for the machinery directly through contracts or through joint-ventures. Appropriate procedures for

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28/ For an estimate of the importance of copper to developing countries, see A/AC.138/36, pp. 34-35.

29/ See section IV.

30/ For other possible methods in this regard, see also section IV.

financial and technical responsibility and agreed time-tables for site development could be included in an allocation scheme. One feature to be encouraged in exploitation arrangements could be various forms of participation by developing countries, thus spreading technological expertise.

59. The crucial question remains: how to make the exploitation policy instrumental in attaining effective management of sea-bed mineral production, so as to obtain the maximum net benefits for the world community with the minimum disturbance of mineral market prices. Perhaps a hypothetical example would be useful in this connexion. Assuming that short- and long-term forecasts of several alternative supply and demand conditions have provided the machinery with the necessary guidelines for desirable development of each sea-bed mineral, the machinery would then be in a position to estimate the maximum increase in nodule production - say, over the next decade - compatible with the established goals of market stabilization.

60. If three mining operations were under way for 1980, 31/ given the joint-products nature of the nodule industry, the markets for cobalt, and possibly manganese, would experience noticeable price drops, while there would be little effect on the nickel market and virtually none on the copper market. If 10 mining operations were under way, the impact on manganese (if produced) and cobalt would probably be severe, 32/ the markets for nickel would experience a more noticeable impact (nodules supplying about 13 per cent of total estimated demand), while copper from nodules would still account for only 1.3 per cent of estimated world demand. Determination of the level of production would require to decide inter alia on the maximum number of new sea-bed mining operations to be allowed for each year and this will require close co-ordination with the use of other regulatory policy instruments. It is assumed for the sake of analysis that one basic objective of the exploitation policy might be to prevent a serious impact on copper markets.

61. Once the policy objectives of the machinery have been decided upon, it will be possible to determine the maximum number of new mining operations for the period considered. If the number of applications for exploitation permits or contracts is greater than the guidelines established some indirect devices (higher initial cash payments and levy per ton of metal produced) and, if needed, direct means (limitation of the number of permits) could be used to discourage production much beyond the desired levels.

62. This procedure would only work if it were possible to establish a sufficient correlation between the number of exploitation permits granted and future

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31/ Assuming a hypothetical standard operation of 1 million tons of nodules per year. See document A/AC.138/36, pp. 52 and ff.

32/ If all these operations decided to recover manganese and cobalt despite the expected price drops.

production forthcoming from those sites, taking into account the likely gestation period. If very large "blocks" of the ocean floor were allocated to interested parties, without some form of control over the number of exploitation permits, there would be little scope in designing an appropriate exploitation policy for market stability. Such a stabilization objective could be attained if permits were granted for an area of the ocean floor sufficient to sustain the full scale operation of say, one mining venture throughout the assumed useful life of the equipment (for example 20 years).

63. The machinery will need to have considerable knowledge of nodule distribution and marine procedures for the administration of this policy. It is known that in some locations nodule density may reach as high as 120,000 tons/km^2, though sites with density as low as 6,000 tons/km^2 may be economically attractive. For the sake of simplicity, it is assumed that the initial choice sites to be exploited would have an approximate density of 20,000 tons/km^2. This means that a site would have to cover only an area of 3,000 km^2 to sustain for 20 years the operation of one mining rig recovering 5,000 tons of nodules per day (300 days/year - assuming 50 per cent nodule recovery).

64. But if the objective of the exploitation policy is to ensure control over production, the simple allocation of an x number of, say 3,000 km^2, sites for exploitation would not be enough. The mining enterprises could, theoretically, produce two, three or even four times the volume of nodules originally envisaged, by putting 2, 3 or 4 rigs in operation on that site. It could be countered that with more intensive utilization than originally intended (say four rigs), the site would be mined out at the end of, say, five years when that enterprise could be excluded from further activities in the international area. This threat would not necessarily discourage the enterprise from going ahead with the use of more than one mining rig on the site. With the existing provisions for accelerated depreciation in most industrial countries, such an enterprise would have probably amortized the whole initial investment in mining equipment, which at that time could be sold or leased to other enterprises. It is important, therefore, that the exploitation policy take into account not only the number of new sites made available, but also the size and number of the mining rigs to be used on the site (in other words the desirable level of production). Therefore, another type of concession could be granted on the basis of a total production volume per year for specific minerals (metals) rather than on the basis of exclusive rights to a given area. An alternative method to control the level of production, other than through concessions (whether by area or by fixed production) would be to have the machinery undertake exploitation itself or maintain a controlling interest through joint ventures or contracts.

(b) The levy of the international machinery

65. The "take" of the international machinery could be made into an effective control instrument to complement the exploitation policy. If the revenues of the machinery were to be derived by means of a levy per ton of mineral (or metal) produced, this levy would act as a "built-in" stabilizer. This device could automatically discourage further recovery from nodules of those minerals facing

obvious situations of over-supply, thus reducing the need for the machinery to intervene with discretionary control measures. The levy per ton would complement the exploitation policy in pursuing the desired long-term market equilibrium and it would also be instrumental in promoting the desired readjustments in cases of unexpected short-term market fluctuations.

66. The way in which the levy per ton of metal produced would function as a built-in stabilizer is quite simple. The ocean mining enterprises would have the following operational function for each metal recovered:

net revenue = market price - (cost of production/ton + levy/ton)

For the sake of simplicity it is assumed that the cost of production of each ton of metal produced is constant. Since the levy per ton would be a fixed sum (or a percentage of market price) adding to the enterprise's costs, in the case of a drop in price of a metal the net revenue of recovering that metal could eventually be wiped out or even turn into a loss. 33/ Therefore, further recovery of that metal would be discouraged. Once investments are made in physical facilities to recover a given metal, production would not be immediately halted by a drop in market price below the level required to cover production costs, overhead, depreciation and a return on investment. Production of the "uneconomic" metal would continue as long as the price (net of levy) would be sufficient to cover the specific operational costs associated with the processing of that metal. The levy per ton, by increasing the actual cost of recovering each ton of metal (cost of production, + levy), or conversely reducing the net price (market price - levy), would make the ocean mining enterprise more sensitive to price fluctuations than the traditional mining ventures. 34/

67. As an example one may take the hypothetical case of manganese, which for the last 15 years has been essentially a buyers market with prices dropping from a high of $145 per ton of manganese content in ore (c.i.f., United States eastern seaboard ports) in 1957 to a low of $54 per ton in 1970. 35/ Given the inelastic nature of demand for manganese, and the existing tendency for over-supply, this is one of the minerals which would be most affected if it

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33/ It may be noted in this connexion that a levy representing an invariable percentage of the market price would affect the selling price of output differently from a levy fixed in money terms.

34/ Many land-based mining operations are, of course, subject to payment of royalties in addition to taxes on profits. The levy per ton envisaged for sea-bed operations would be the equivalent of the sum total of royalties, corporate tax, and other fiscal charges paid by traditional mining ventures.

35/ UNCTAD, TD/B/C.1/105, Problems of the world market for manganese ore, table A.14.

is produced from nodules. Moreover, several developing countries are exporters of manganese ore, hence the particular interest in stabilizing this market.

68. At the present market price for manganese ore ($60 per ton at 48 per cent Mn), it is not likely that production of manganese ore equivalent from nodules could become competitive with land producers, if it were subject to a levy per ton equivalent.

69. The recovery of manganese from nodules is known to be the most complex and costly stage of the metallurgical processing. One estimate for instance, 36/ puts the cost of recovering a low-grade manganese ore equivalent at $45 a ton. The same author estimates that the Mn-Fe in the nodules might be valued at $35 per ton. Despite the many unknowns in the equation, it is the general consensus of experts that the recovery of a manganese-ore equivalent from nodules would at best be of marginal interest. (See section II.) Indeed, several designs of metallurgical processing under consideration do not provide for the recovery of manganese.

70. One of the advantages of the levy per ton as an indirect control device is that it could be tailored to discourage additional supply when prices drop to a minimum acceptable floor. Based on the estimated cost of manganese recovery from nodules, the levy per ton could be set in such a way as to make manganese recovery clearly uneconomical if prices were to drop below the desirable floor level.

71. Notwithstanding the considerable disincentive implied in the considerations above, a certain extent of manganese recovery might still remain in the realm of possibility. First, some Governments in major industrial countries dependent on manganese imports, might wish to subsidize manganese recovery, in order to diversify sources of supply. Second, it is very likely that most of the manganese that might eventually be supplied by the nodule industry would be in the form of a different commodity, superior for certain purposes to that supplied by land-based mines. This means that the plants that might recover manganese would probably produce ferro-manganese or pure manganese metal. The market for ferro-manganese is, of course, much smaller than that for ore. At present, only a few industries require pure manganese metal and it is estimated that the production from one single nodule operation would be enough to supply the present world demand. However, it is conceivable that the steady large-scale

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36/ John Mero, "Potential economic value of ocean floor manganese nodule deposits", paper presented at the Conference/Workshop on Ocean Manganese Deposits, at the Lamont-Doherty Geological Observatory, New York, 21 January 1972.

availability of this commodity might eventually induce an increasing number of industries to use pure metal even if it cost much more than high-grade ore. 37/

72. The possibility of change in the structure of manganese markets, with an increase in the shares of ferro-manganese and pure metal, although hypothetical, is indicative of the complexities involved in effectively implementing the stabilization objectives that might be desired by the world community.

73. Another attractive feature of the levy per ton is its efficiency as an instrument to collect revenues. If the "take" of the machinery were based on the net revenues of the marine mining ventures, it is conceivable that the yields might eventually be disappointing. Prices of some minerals in the absence of controls might drop with the expansion of the nodule industry, thus reducing the net revenue of marine mining enterprises to the point where nodule mining would be only marginally profitable. At this stage the nodule industry would be the major supplier of cobalt, nickel, and perhaps manganese, and an important producer of copper, but net revenues would be quite modest, thus depressing the "take" of the machinery if based on net revenue. On the other hand, if a levy per ton of mineral recovered from nodules were imposed, the revenues of the machinery would increase pari passu with the expansion of sea-bed mineral production. The international community would therefore have considerably larger revenues at its disposal.

74. The levy per ton would also have the advantage of simplicity. Great difficulties can be foreseen in any attempt to translate the existing fiscal structures, applicable to petroleum and mining, into those that will eventually operate in the area beyond national jurisdiction. A rather large and cumbersome machinery would be required to administer such a "fiscal" system and recurrent contentions could be expected in the determination of taxable "profits" or net revenues. These difficulties might be overcome by instituting a single levy per ton of mineral (or metal) to be produced from the area.

75. While the actual operation of the levy system could be expected to be simple and straightforward, the initial determination of what these levies would be is by no means simple. Various factors determining the economics of each operation would have to be taken into account and, in particular, the implications of simultaneous production of several joint-products.

(c) Compensatory measures

76. The third component of a broad strategy to minimize the possible adverse impact of sea-bed exploitation would be some form of compensatory measures. As

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37/ It has been suggested in industrial circles that electrolytic pure manganese metal might be sold at around $US 0.30 per pound, that is, 10 times more than the price of manganese ore. The price of ferro-manganese ranges between 3.5 to 4 times that for ore ($180 to $220 per ton).

pointed out before, the nature of the nodule industry and the exploitation and "fiscal" policies of the machinery indicate that in the early stages of sea-bed mining only the exporters of cobalt and perhaps manganese might be affected, and this raises the question of compensatory assistance.

77. The design and management of compensatory schemes would involve some complex issues (see section IV of this report). Detailed studies will be required of alternative schemes and their implications for the traditional developing countries exporters of the minerals affected.

(d) Other arrangements

78. Additional measures for market stabilization of some minerals might also be desirable in the future. As noted in the previous report (A/AC.138/36), commodity agreements are generally designed to maintain the status quo among suppliers and as such would be of limited relevance in the initial stages of sea-bed mining.

79. These arrangements are generally difficult to administer. Section IV deals with the possible scope of commodity arrangements for the mineral markets that might be affected by sea-bed mining.

IV. SOME ISSUES OF INTERNATIONAL COMMODITY POLICY 38/

80. The following notes are designed to throw light on the nature of the economic effects, particularly upon world markets, of production of minerals from the

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38/ This section ccntains the main part of a report (TD/113/Supp.4), prepared by the UNCTAD secretariat for the third United Naticns Conference on Trade and Development, which briefly discusses, in the light of information so far available on the subject, the main issues of international commodity policy arising from the potential production of minerals from the area of the sea-bed beyond the limits of national jurisdiction.

At the sixth session of the UNCTAD Committee on Commodities the UNCTAD secretariat reported on its co-operation with the Department of Economic and Social Affairs of the United Nations in the preparation of relevant studies pursuant to General Assembly resolution 2750 A (XXV). In the discussion of this subject at the Committee's sixth session, representatives of developing countries stated that they attached great importance to the subject matter of General Assembly resolution 2750 A (XXV); that the co-operation envisaged in the resolution should be regarded as referring to UNCTAD at the intergovernmental as well as the secretariat level; that provision should be made for the Committee on Commodities to be informed of, and to discuss, developments in this field on a continuing basis; and that an opportunity should be provided for an examination of the matter at the third session of the Conference. (TD/B/370, paras. 234-236.) Similar views were expressed at the eleventh session of the Trade and Development Board. (See the Board's report on that session, Official Records of the General Assembly, Twenty-sixth session, Supplement No. 15, part three, paras. 152-153.)

sea-bed, and on the character of possible arrangements to obviate, remedy or minimize any adverse impact of such production on developing countries which are established land producers of the minerals concerned.

81. The mineral resources of the sea-bed which, in the light of present knowledge, are most likely to be commercially exploitable in the foreseeable future are "manganese" nodules - containing copper, cobalt, manganese and nickel - and, less immediately, petroleum and natural gas. 39/ 40/ Pilot-scale mining of manganese nodules has already been carried out, and it is reported that a syndicate expects to start exploiting particular nodule deposits in the Pacific Ocean within a few years. 41/ The volume of manganese nodules on the sea-bed is reported to be vast, and to be growing at an estimated annual rate which exceeds the present annual consumption of the component metals. 42/ The proportions of the various metals contained in manganese nodules differ from those of current world metal requirements as reflected in the composition of world production of 1968, as the following figures show:

	Metal in sea-bed nodules	Metal in world production
	(per cent)	
Manganese	90	56
Copper	4.5	40
Nickel	4.6	4
Cobalt	0.9	(0.15)
	100	100

The developing countries at present account for the bulk of international trade in manganese ore, cobalt and copper, but for only a small proportion of trade in nickel.

82. In considering the implications of production of minerals from the sea-bed, allowance should be made for the possibility of new major mineral discoveries on the sea-bed in the future, as well as for future improvements in the techniques of mining from the sea-bed, and thus for the possibility that production could occur on a larger scale, and cover a wider range of minerals, than can be foreseen at the present stage.

39/ For a useful summary of presently available information on the prospects of exploitation of the mineral resources of the sea-bed, see document A/AC.138/36.

40/ Ibid., para. 10.

41/ Ibid., para. 139.

42/ Ibid., para. 152.

A. General nature of consequences

83. Since the sea-bed would constitute a completely new source of supply of whatever mineral was being produced, and since it can reasonably be assumed that such production would not occur unless it was competitive with output from land sources, sea-bed production would tend to have a depressing effect on the market price of the mineral concerned. The magnitude of the impact upon supplies and prices would depend upon the technical qualities of the sea-bed mineral, the particular circumstances of sea-bed production - the volume of additional supplies in comparison with land-based output, the costs of production and marketing, and taxation rates - as well as upon the conditions of supply and demand, including the responsiveness of prices to a given increment in supplies. If the pre-existing situation with regard to the mineral concerned was one exhibiting an upward trend in the mineral's price, the effect of sea-bed production would be to slacken or halt, or even reverse, the upward trend; if, on the other hand, the market price was constant or declining, the effect would be to bring about a decline or to accentuate a pre-existing decline. Generally speaking, therefore, although reliable quantification is not possible - both because of the absence of firm information on the circumstances of sea-bed production and because of the intrinsic difficulties of estimating market effects - the introduction of sea-bed production could be expected to result in a lower market price of the mineral(s) concerned than would otherwise have prevailed.

B. Consequences for consuming countries

84. It follows from the foregoing that the greater availabilities and presumed lower marginal costs associated with the production of minerals from the sea-bed would bring direct benefits to the consumers of the minerals concerned, who are, by and large, the mineral-using industries in developed countries. As is typical in primary production, the productivity gain resulting, in this case, from technological progress making lower-cost sea-bed production possible would be largely passed on to the consumers, in the form of lower prices, in the absence of any countervailing measures. 43/

43/ Compare Nicholas Kaldor's remarks that "whereas the benefits of technical progress in manufacturing are largely retained by the producers (in the form of higher real wages and profits) the benefits of technological progress in primary production are largely passed on to the consumers, in the form of a higher real income. (The exceptions to these are to be found in those cases - such as oil - where the distribution of the commodity is controlled by large international concerns.)". "Stabilizing the terms of trade of under-developed countries", Economic Bulletin for Latin America, vol. VIII, No. 1, March 1963.

C. Consequences for land producers

85. As previously mentioned (para. 83), sea-bed production would exert a downward pressure on the market prices of the minerals concerned. This would happen particularly in the case of those minerals, such as cobalt and manganese, which would be jointly mined with the more valuable minerals, nickel and copper, and which would be recoverable from manganese nodules in relatively greater proportions than those of world demand for the component metals. 44/ The strong possibility of a sharp impact of sea-bed mining upon the market prices of certain minerals is indicated by illustrative calculations which show that five sea-bed mining operations, each harvesting 5,000 tons of nodules per day, would yield, annually, quantities of manganese equivalent to over one half of the current annual rate of manganese exports of the developing countries as a group, and quantities of cobalt equivalent to the entire annual cobalt output of the developing countries. 45/

86. Secondly, because aggregate demand for many minerals is not very responsive to falls in their prices, output from the sea-bed would tend to displace marginal land production (or such land output as was previously marketed in the country in which the new supplies emanating from the sea-bed were consumed). This adverse quantitative effect would be compounded by the restrictive effects on land production of its diminished profitability and the accompanying decline in investment resources.

87. The over-all consequence of the price and volume effects mentioned in paragraphs 85 and 86 would be that the total earnings of land producers from the minerals concerned would decline or would grow less rapidly than they would have done otherwise - in any event, they would be smaller than in the absence of production from the sea-bed. The severity of the impact would vary among countries and producing enterprises according to relative efficiencies, patterns of trade and market structures.

88. However, as world demand for the minerals concerned is expected to continue growing, at rates of possibly 5 per cent or more per year, the addition of supplies from the sea-bed would not necessarily prevent established producers from land-based sources from expanding their own exports, and would not necessarily result in declines in market prices below pre-existing levels. 46/

44/ The incremental cost of recovery of the mineral from the nodules, in relation to the prevailing market price, would be a further relevant factor.

45/ Document A/AC.138/36, tables 1 and 17 and paras. 155-160.

46/ The more rapid the growth of world demand for a particular mineral, the greater is the possibility of concurrent increases in available supplies from both the sea-bed and land sources without a resultant decline in market prices. Thus, if cobalt were increasingly used as a substitute for nickel, world requirements of cobalt would increase much more rapidly than they would otherwise, and the impact of a given volume of marine production of cobalt on market prices would be moderated. (In that event, however, a given volume of nickel recovered from nodules would have a more severe impact on the market price of nickel than it would otherwise.)

On the other hand, mineral sea-bed production could not be assumed to have such a moderate impact on world mineral markets unless the rates at which new supplies were marketed were strictly controlled by the international authority which it is envisaged should be established.

89. Although the most important effect of sea-bed production of minerals on world markets concerns the trend and level of prices of the commodities in question, such output might also accentuate short-term price fluctuations. This might occur if the flow of supplies from the sea-bed was irregular; it might also occur if the bulk of sea-bed production was undertaken by vertically integrated commercial enterprises, with the concomitant result that the world's "free market" for each mineral concerned would account for a declining proportion of total physical transactions, so becoming more of a residual market with greater price sensitivity to given changes in supply or demand.

90. The economic impact of competing production of minerals from the sea-bed, which might be expected to be adverse to varying extents for the export incomes of all established producers (in relation to the incomes which they would otherwise earn), might be particularly adverse for typical developing producing countries. This could be so for a variety of reasons:

(a) Developing producing countries typically depend more heavily on the minerals concerned (such as copper and manganese ore) for their export incomes and government revenues than do developed producing countries;

(b) The share of developing countries in world trade in certain minerals (notably manganese ore) has been declining owing to the more rapid progress made in the developed countries' production for export;

(c) The developing countries are likely to participate directly to only a small degree in the production of minerals from the sea-bed, for, because of its technically sophisticated nature and its high capital requirements, this production will no doubt be undertaken principally by interests from the affluent and technologically advanced countries;

(d) Developing countries, which are increasingly processing land minerals before export, would lose such potential export income to the extent that minerals produced from the sea-bed were processed on the mainland of the producing enterprise's "home country". Moreover, the stimulus which sea-bed production would undoubtedly impart to the existing technological trend towards the direct processing of mineral concentrates, and the avoidance of intermediate processes which are now partly carried out in developing producing countries, would aggravate the loss of potential export income on the part of developing countries;

(e) The need for large-scale capital investments for the exploration and mining of sea-bed resources might adversely affect the flow of private investment into similar activities in developing countries;

(f) Because fewer alternative investment and employment opportunities exist in developing than in developed countries, particularly heavy economic and social costs will be incurred in any reallocation of resources that may be necessitated by the competition from sea-bed production.

D. Some implications for policy

91. The essential problem which would arise from the production of minerals from the sea-bed would thus be the adverse impact of such production - in the absence of special arrangements - on the economic well-being of the developing producing countries concerned, and the consequential difference between the social costs and benefits of sea-bed production and its costs and benefits judged simply in terms of normal commercial criteria. The implication of this conclusion for international policy is that firm arrangements would be required in advance of the production of minerals from the sea-bed in order to ensure that such activity would not adversely affect the interests of developing producing countries or, better, would bring them, and to other developing countries, positive benefits.

92. There would appear to be two possible approaches to the problem of protecting the trade interests of the developing countries which are established exporters of the minerals in question: (a) an approach designed to obviate or minimize any potential adverse effects; and (b) an approach under which the affected countries would receive compensation for the estimated adverse impact upon their export earnings.

(a) The preventive approach

93. The preventive approach would consist essentially of arrangements to ensure that output from the sea-bed will not result in prices which are not remunerative to reasonably efficient developing countries which are established producers of the minerals concerned (from land-based sources). For this purpose, it would be necessary that the rate of production from the sea-bed, or the rate of disposal of such output, or the selling prices or related terms of its disposal, should be strictly controlled by the proposed international authority, in order that the market prices for the minerals concerned are not depressed below levels declared by the international community as remunerative and equitable. Thus, an appropriate pricing policy might involve the setting of "floor" selling prices in respect of output from the sea-bed, supplemented by the imposition as necessary of import levies by importing countries in order to forestall price-cutting by any private producers who might be permitted to operate under the international régime. 47/ If such import levies were imposed, the proceeds would presumably be remitted to the sea-bed authority.

47/ The arrangements should be kept as simple as possible. If, however, it became necessary to conclude comprehensive international commodity arrangements for the minerals concerned, in order effectively to protect the interests of producing developing countries, the operation of an international buffer stock of each relevant mineral by the international authority could, as in the case of the International Tin Agreement, be a useful adjunct to other measures for maintaining prices within any agreed price ranges.

94. If the interests of established producing countries were protected through the setting of minimum selling prices for sea-bed minerals at levels designed to be remunerative to producers from land-based sources, a greater proportion of the net revenues of the sea-bed authority would become available to assist the economic development of non-producing developing countries, including land-locked countries, as envisaged by the General Assembly in its resolution 2750 A (XXV).

(b) The compensatory approach

95. Under the alternative, compensatory approach referred to in paragraph 92, compensation would be paid to developing exporting countries whose interests were adversely affected by production of minerals from the sea-bed. This compensation would be paid to the extent possible out of the net revenues accruing to the international authority from the exploitation of the sea-bed, either in the form of royalties, fees and taxes (if the international authority did not itself carry out the production activities), or in the form of profits (if the sea-bed authority engaged directly in the exploitation of the sea-bed). By means of this approach, an appropriate proportion of the net receipts of the sea-bed authority would be utilized for the purpose of compensating developing producing countries.

96. The formulation of workable compensation arrangements would, however, pose issues of considerable complexity. One issue relates to the criteria by which the extent of the "adverse impact" on the producing countries concerned would be measured: one possible yardstick might be the extent of any shortfall of proceeds from exports of the mineral(s) concerned below recent realized levels, or below the levels they might reasonably have been expected to reach in the absence of sea-bed production; allowance might or might not be made for the loss of benefits from any additional processing of the mineral suffered as a result of sea-bed production. Other issues are whether the arrangements should be on a commodity-by-commodity basis, or should cover collectively all the minerals concerned; whether the arrangements should have a specified duration, and how frequently they should be reviewed. Regarding the apportionment of compensation funds, the amount of the compensation should presumably be assessed by reference to the potential export income lost as a result of sea-bed production, account being taken also of total foreign exchange availabilities, the degree of development of the country concerned and the scope for alternative employment of manpower and other resources.

97. A critical question relating to the compensatory approach is whether the net income of the sea-bed authority would be sufficient to implement a programme of compensation payments as outlined above. Although it is impossible to be precise on this point, it would seem that, in cases in which the developing countries accoutn for most, or an appreciable part, of the international trade in the minerals in question, the net income accruing to the proposed international authority from sea-bed production would almost certainly fall short of the amount required to compensate developing producing countries for export proceeds lost as a result of sea-bed production, if the loss were regarded as including the growth of exports which would have otherwise taken place. This would be

true in the case of cobalt, manganese ore 48/ and copper, although probably not in the case of nickel, in the world exports of which the developing countries account for only a small proportion. There are two reasons why the loss in export earnings would probably exceed the net revenue of the sea-bed authority: first, the demand for most minerals is such that, other things being equal, an increase in available supplies often leads to a more than proportionate decline in prices, with a resultant fall in total proceeds; second, the net revenues of the sea-bed authority could not realistically be expected to exceed 10-30 per cent of the gross proceeds from the sale of sea-bed minerals, with the possible exception of petroleum. In these circumstances, in order to apply the compensatory approach, it would seem necessary that arrangements should be made to ensure that the shortfall in the required amount of financial compensation would be made good by consuming countries and/or the international financial institutions.

98. On the other hand, if developing exporting countries were to be compensated merely with a veiw to sustaining their historical export incomes from the minerals concerned, the net revenues of the sea-bed authority might well be sufficient for the purpose, although even this would be somewhat doubtful in respect of cobalt, manganese ore and copper. In any case, the latter, static approach would appear to be inconsistent with the International Development Strategy for the Second United Nations Development Decade, which envisages a positive contribution to meeting the trade and development needs of the developing countries through the formulation of a coherent set of international measures for development.

E. Other considerations

99. Whatever the nature of the arrangements made to protect the interests of the developing producing countries, a fundamental condition concerning sea-bed production should presumably be that no overt or disguised stimulus should be given to such production, since it would be at the expense of the mining industries on land, including those of the developing countries. As a corollary to this condition, if production activities were carried out by national enterprises, rather than directly by the international authority, provisions as to taxation and the conditions governing entry of the product into the home country of the producing enterprise, should be such that supplies originating from the sea-bed should not receive preferential treatment by comparison with land production. Consideration would also need to be given to the possibility of avoiding the inbuilt "preference" for sea-bed production which would arise from the carrying out of such production by integrated enterprises based in developed countries.

48/ For example, in respect of manganese ore, it has been estimated that one sea-bed mining operation would result in a loss of potential export income to land-based producers of manganese ore amounting to about $15 million per year (document A/AC.138/36, annex II, para. 36).

100. In view of the possibility of market disruption, it would seem important to ensure, from the outset, that particular sea-bed mining projects would result in an over-all net gain to the international community, and especially to developing countries. The General Assembly, in resolution 2750 A (XXV), envisaged the transfer to non-producing, including land-locked, developing countries of equitable shares of the benefits derived from the operations of the sea-bed authority, as well as the protection of the interests of producing developing countries. This particular objective would seem to call for the imposition of the maximum rates of royalties, taxation and fees which "the traffic will bear" in regard to sea-bed production, if the international authority did not itself carry out the production activities. The combined imposts should, at minimum, have an incidence at least equivalent to that of the average of national imposts on land production of the minerals concerned.

A CONCLUDING REMARK

101. In submitting this report, the Secretary-General is fully conscious of the fact that very considerable additional work will have to be carried out in order to explore the various approaches which could conceivably be applied to the problems under study. In accordance with resolution 2750 A (XXV), the Secretariat will endeavour, in co-operation with UNCTAD, to provide to the Committee, when appropriate, additional information and reports on the complex and rapidly changing subject of possible effects of sea-bed mining on world mineral markets.
