UNITED NATIONS

GENERAL ASSEMBLY

Distr.
GENERAL

A/AC.138/87
4 June 1973

ORIGINAL: ENGLISH

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

ECONOMIC SIGNIFICANCE, IN TERMS OF SEA-BED MINERAL RESOURCES, OF THE VARIOUS LIMITS PROPOSED FOR NATIONAL JURISDICTION

Report of the Secretary-General

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INTRODUCTION

At its 2114th plenary meeting, held on 18 December 1972, the General Assembly adopted resolution 3029 (XXVII) entitled "Reservation exclusively for peaceful purposes of the sea-bed and the ocean floor and the subsoil thereof underlying the high seas beyond the limits of present national jurisdiction and use of their resources in the interests of mankind, and convening of a conference on the law of the sea".

In resolution 3029 B (XXVII), the General Assembly, realizing that the economic significance of the area would depend on its final delimitation, considering that there is a close relationship between any decision concerning the activities and functions of the international machinery and any decision concerning limits, and convinced that information and data on the economic implications and significance for the area of the various proposals for limits would be helpful to the participants at the forthcoming United Nations Conference on the Law of the Sea, requested the Secretary-General to prepare, "on the basis of data and information at his disposal, a comparative study of the extent and the economic significance, in terms of resources, of the international area that would result from each of the various proposals on limits of national jurisdiction submitted so far to the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction". States, the United Nations Conference on Trade and Development, the specialized agencies and other competent organizations of the United Nations system were invited to co-operate with the Secretary-General in the preparation of the study.

In resolution 3029 C (XXVII), the General Assembly, convinced of the importance to coastal States for purposes of economic development and social progress of the ocean resources adjacent to their coast, requested the Secretary-General to prepare, "on the basis of the information at his disposal and in connexion with the study" under resolution 3029 B (XXVII) mentioned above, "a comparative study of the potential economic significance for riparian States, in terms of resources, of each of the various proposals on limits of national jurisdiction presented so far to the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction".

The General Assembly also declared that nothing in the resolution or in the studies "shall prejudice the position of any State concerning limits, the nature of the régime and machinery or any other matter to be discussed at the forthcoming United Nations Conference on the Law of the Sea".

The Secretary-General was requested to submit the two studies referred to above before the summer session of the Sea-Bed Committee in 1973.

In pursuance of the resolution, a note verbale, dated 5 January 1973, was sent to all Member States of the United Nations requesting them to forward information at their disposal on sea-bed resource potential, in particular, mineral resources. As of 10 May 1973, replies were received from 13 States.

The United Nations Conference on Trade and Development (UNCTAD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) were also requested to supply to the Secretariat any relevant information which they might have at their disposal in this regard. The substantive parts of the replies are reproduced in annex 1 to this document.

In implementing this resolution, the Secretary-General has also taken into account the relevant views of Member States expressed during the debate on the resolution at the twenty-seventh session of the General Assembly. Special reference should be made to the view which was generally expressed that the studies should be factual and be based on existing data and information at the Secretary-General's disposal, and that the Secretary-General should make no attempt to draw conclusions and consider implications for individual countries, or to comment on the various proposed limits. Accordingly, the Secretary-General has not analysed the implications of the words "economic significance", whether for the international area or coastal States, apart from the endeavour to assess resources, although such significance may be affected by various factors, including, in particular, the legal régime applicable and the extent of existing rights.

At the time of adoption of resolutions 3029 B and C (XXVII), the Secretary-General had occasion to stress the limited and general nature of the existing information available on the extent and location of sea-bed minerals and he noted that it was not such as to permit an in-depth analysis of the mineral potential or economic significance for all proposed limits. Since the resolution specified that the studies were to be based on "data and information at his disposal", the Secretary-General has concentrated the analysis on the only proposed limit figures for which material was available. These fall into two categories of limits. The first category is based on depth criteria (i.e. the 200 metres isobath and 3,000 metres isobath) and the second on distance criteria (i.e. 40 nautical miles and 200 nautical miles).

It will be noted from the structure of this report that the Secretary-General has chosen to combine in one report the information requested in resolutions 3029 B and C (XXVII). This appeared necessary to avoid duplication since the same data were used for both analyses. The study has been divided into two parts. Part I sets out basic information concerning sea-bed mineral resources. After a description of the factors determining the economic significance of resources, separate chapters are devoted to hydrocarbons, manganese nodules and other minerals. Part II deals with the economic significance of sea-bed resources, the assessment made being related to each of the four limits mentioned above. The material is arranged in parallel columns so as to show, on the left hand side, the situation as regards the international area and, on the right hand side, the situation as regards coastal States.

In preparing this report, the Secretary-General has relied on materials available to him and, more specifically, on information supplied by consultants:

Mr. Lewis Weeks (United States) on hydrocarbons; and Messrs. Herbert Drechsler (United States), Georgi Zahariev (Bulgaria) and Allotey Odunton (Ghana) on manganese nodules. The drafts were reviewed by high-level experts: Messrs. Yuri B. Kazmin (USSR), Alirio A. Parra (Venezuela), Donald F. Sherwin (Canada) and Alan A. Archer (United Kingdom). The comments and contributions of these experts have been incorporated in the text. The Secretary-General appreciates highly their valuable co-operation in the preparation of this report.

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I. BASIC INFORMATION: SEA-BED MINERAL RESOURCES

1. Factors determining the economic significance of resources

An evaluation, even of a general nature, of the geological potential of the sea-bed is a most difficult task. But an assessment of the economic significance of the resources known or surmised to be present on or below the sea-bed is even more of a challenge. It not only requires geological data and knowledge of the engineering systems which would be required for the recovery and processing of mineral deposits, but also estimates of operational costs and market value of the commodities to be produced.

Assuming that the existing estimates of the volume of mineral resources of the sea-bed accurately depict geological reality, it should still be remembered that it is not the quantity that is relevant but the economic value of the resources. For example, it has been estimated that there are about 5 million metric tons of gold in the oceans. 1/ Assuming the price of $US 10 per troy ounce, this gold would be worth some 17,500 billion dollars. However, this enormous amount has not induced anybody to start extracting this gold, the reason being simply that costs of production would be far greater than the revenues that could be derived.

The relative economic significance of mineral deposits, including those on the sea-bed, is distinguished in the generally accepted definitions of "mineral reserves" and "mineral resources". 2/ Mineral reserves are identified deposits that are exploitable under the current, locally prevailing economic circumstances. Mineral resources are deposits not yet discovered but assumed to exist on the basis of general knowledge of geology as well as identified deposits that cannot be economically recovered at currently prevailing conditions but which may have some foreseeable use and likely value. 3/

1/ F. T. Christy, Jr., "Marigenous Minerals: Wealth, Régimes, and Factors of Decisions", Symposium on the International Régime of the Sea-Bed: Proceedings (Rome: Accademia Nazionale dei Lincei, 1970), p. 115.

2/ Blondel, F. and Lasky, S. G., Mineral Reserves and Mineral Resources; Economic Geology and Bulletin of the Society of Economic Geologists, vol. 51, No. 7 (1956), pp. 686-697.

3/ The terms recoverable, marginal and submarginal designate successively lower degrees of economic recoverability; marginal resources are defined as low-grade resources that are recoverable at prices as much as 1.5 times those prevailing now, and submarginal resources are those of still lower grade. Identified deposits of marginal and submarginal grade would be called conditional reserves; they may eventually become reserves when conditions of economics or technology are met. McKelvey, V. E., 1972, "Mineral resource estimates and public policy", American Scientist, vol. 60, No. 1, pp. 32-40.

Resources can also be classified according to the degree of certainty of their existence. Undiscovered minerals would make up the remaining potential resources, and could be classified as hypothetical resources, or undiscovered resources that might still be found in known districts; and speculative resources, or undiscovered resources that may exist elsewhere, either conventional types of deposits or else unconventional types of resources that have only recently been recognized (or are yet to be recognized) as having some potential. 4/ These various types of resources are summarized in figure I.

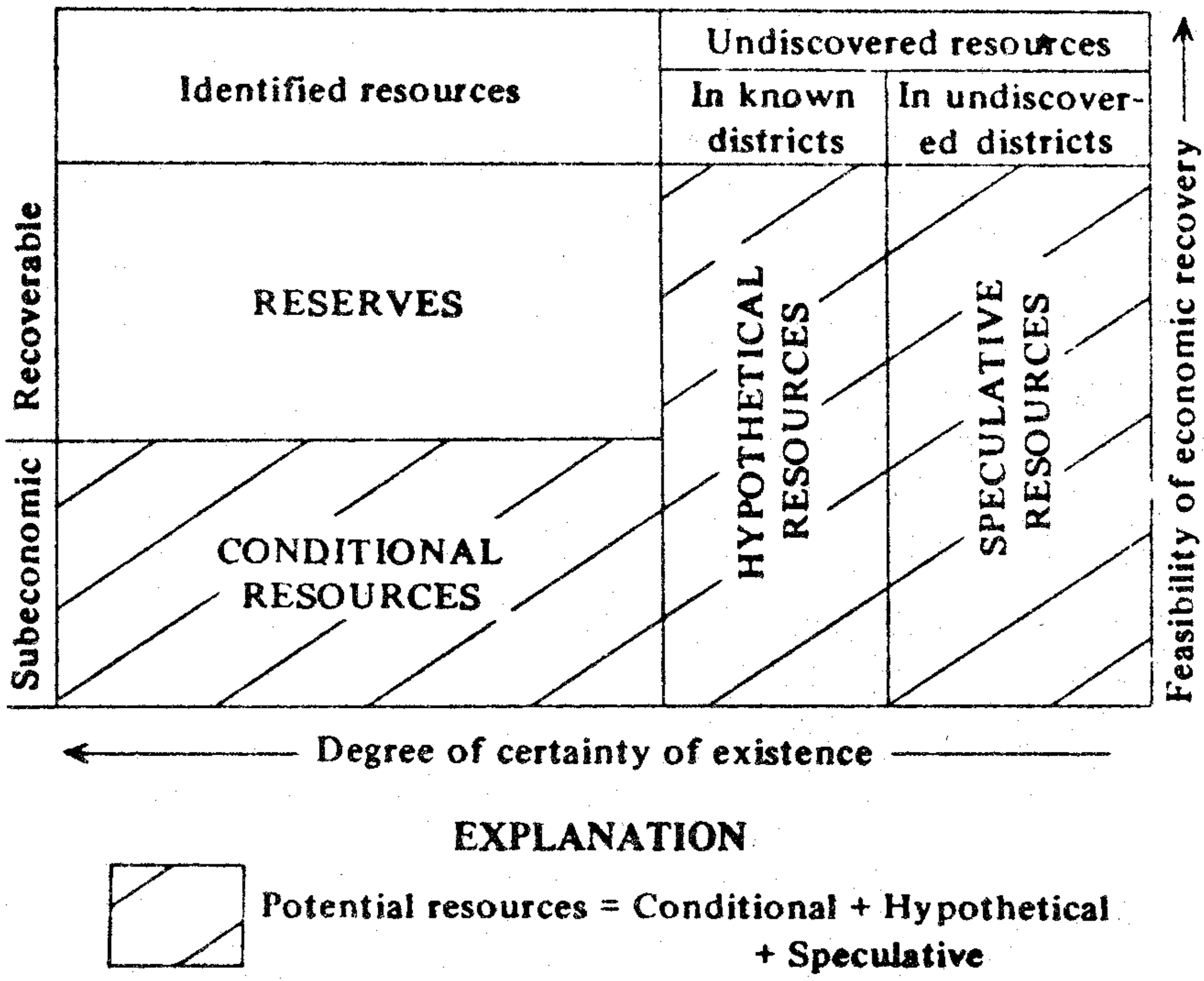

FIGURE I.—Classification of mineral resources used in thi[s] volume.

4/ D. A. Brobst and W. P. Pratt (ed.), United States Mineral Resources Geological Survey Professional Paper 820, pp. 3-4.

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In the case of sea-bed minerals, the only minerals that can be regarded as reserves are those that can be commercially exploited at present. Manganese nodules and metalized muds, for instance, must be regarded as resources.

Technological innovations may reduce costs and enable "resources" to be promoted to reserves. For example, at the beginning of this century, the average grade of commercial copper deposits being mined was about 3 per cent; today, deposits with less than 0.5 per cent copper are being mined successfully.

Having drawn this basic economic distinction between a "reserve" and a "resource", there are still numerous factors to be considered in any assessment of resource potential. As will be seen from the following sections these include: depth of water and distance from shore; distribution and grade of ore; size of deposit; accessibility of mining site; processing capability; market prices and forecasts of the supply/demand position. Not all such factors apply equally to all of the minerals discussed. Depth and distance, for example, are severe limitations for the petroleum industry, the deepest well at present being at a water depth of about 150 metres; while distribution and grade of ore relate more to manganese nodules.

2. Hydrocarbons

(a) The off-shore oil industry

Of the 135 countries considered to have petroleum prospects, 100 show evidence of off-shore activity, and in the majority of these, the interest is primarily or only in off-shore oil or gas. Geological studies using geophysical techniques, are being carried out off 65 countries and drilling off about half of these. Forty countries are presently producing or about to produce oil or gas from the continental shelf, or have made promising discoveries.

In 1972 world oil production passed 50 million barrels a day or 18.25 billion (10^9) barrels a year. About 3.3 billion barrels, that is 18 per cent, of the 1972 oil production came from off-shore deposits. Of a 1971 world gas production of about 50,000 billion cubic feet, about 10 per cent was produced off-shore. World proved reserves of oil and gas are estimated at 640 billion barrels and 1,900,000 billion cubic feet respectively. Of these reserves, the sea-bed now accounts for about 18 per cent of the oil and 9.5 per cent of the reported gas.

World production of oil increased at 11.5 per cent a year from 1950 to 1960 and at 13 per cent a year from 1960 to 1970. However, in 1972 it increased by only about 6 per cent. In the past the annual increase in consumption of petroleum energy has varied rather closely with economic conditions in the principal consuming nations. Thus economic conditions over the next eight years in the major consuming areas will have a definite bearing on the size of the demand for petroleum energy in 1980, as will the critical economics of supply off-shore in relation to on-shore, for a continuously increasing percentage of the world's petroleum energy will have to come from the sea-bed. Although the

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ratio of world off-shore to on-shore proved reserves is nearly one to five, the unproved potential off-shore and on-shore resources are more nearly equal. 5/

Thus the future is expected to bring a progressive increase in the ratio of off-shore discoveries, proved reserves and production to those on-shore.

World expenditure on off-shore oil and gas exploration and exploitation operations for the year 1972 is estimated at approximately $4 billion. Expenditure will have to be more than doubled by the year 1980 if the potential markets are to be supplied.

The total value of world off-shore petroleum production in 1969 was $6.1 billion. 6/ The current monetary value of off-shore petroleum production is estimated to be about $9.5 to $10 billion annually.

(b) Hydrocarbon potential according to off-shore physiographic provinces

Physical characteristics

The outer edge of the physical continental shelf has often been taken at 100 fathoms, 600 feet, or at 200 metres of water depth. Actually, it averages somewhat less, about 130 metres, and varies from 20 metres to as much as 650 metres. The width of the shelf ranges from as little as ten to several hundred miles. 7/

The gradient of the sea-bed increases markedly beyond the shelf. The upper, steeper, part is known as the continental slope and the gentler, deeper, part from the foot of the continental slope to the abyssal plain or deep ocean floor is generally referred to as the continental rise. The shelf, slope and rise constitute the continental margin.

The continental rise is wide off much of the eastern coast of North and South America, in the Arabian Sea and Bay of Bengal, off eastern Africa, and off much of western Africa. In other words the rise tends to be widest off stable coasts, where it may extend to as much as 900 miles from shore. On the other hand, off mobile coasts much of the rise and slope sediments have been carried downward and incorporated into the continental crust, through processes associated with continental drift and sea-floor spreading. Rise sediments extend across the entire bottom of many of the small ocean basins.

5/ Based on Dr. Weeks' estimates.

6/ Report of the Secretary-General on the mineral resources of the sea (E/4973, 26 April 1971).

7/ In this context, the shelf is considered as the zone around the continent extending from the low-water line to the depth at which there is a marked increase of slope to greater depths (International Committee on the Nomenclature of Bottom Features).

The sediments beneath the slopes and rises and beneath the small ocean basins may attain greater thickness and volume than those under the neighbouring shelves. Recent upper slope sediments commonly contain a somewhat higher average proportion of organic matter than those of the shelf. It is not known how generally this may apply to the underlying, older, sediments beneath the slope. The rise and lower slope sediments are now mainly being deposited in a rather oxidizing environment, which is not generally favourable for the preservation of the organic matter which is the probable source of petroleum. However, there is substantial geological evidence that conditions at certain times in the past may have favoured the accumulation of petroleum under the lower slope and rise.

There are large differences in the area of land draining into the three oceans today affecting sedimentation. Thus, the volume draining into the Atlantic (nearly 43 million sq km) is about four times that draining into the Pacific, and it is also nearly four times that which drains into the Indian Ocean. This and the degree of activity in past geologic history has an important bearing on the nature, magnitude, and geographical and age distribution of petroleum beneath the ocean floor.

Assessment of hydrocarbon potential

The prediction of potential undiscovered reserves of petroleum and natural gas is an imprecise and speculative art, fraught with so much subjectivity and intuitive interpretation that the subject has been compared with crystal ball gazing. The accuracy of the results varies with the amount of geological information available, and as the distribution of adequate geological data from drilling and geophysical surveys is very irregular and, in the case of most of the area beyond the continental shelf, virtually non-existent, assessments of off-shore hydrocarbon resources are particularly conjectural. They all constitute at best an educated guess and are only useful in providing relative orders of magnitude. Techniques which have been applied to the evaluation of on-shore hydrocarbon potential for a number of years are equally appropriate for off-shore regions, particularly those regions which are extensions of, or similar to on-shore petroleum basins which have had some significant history of successful exploration and production. But it should be understood that only after wells are drilled can the existence of hydrocarbon accumulations be actually established.

Geological estimation methods were used to compile the figures on ultimately recoverable petroleum presented in this report. This approach is based on the premise that a given volume or area of sedimentary rock in a basin which is favourable for hydrocarbon generation and entrapment should ultimately yield a predictable volume of hydrocarbons, if the geological history and characteristics of the basin, and industrial experience in similar but more extensively explored basins is taken into account. The ultimate potential reserves are then the volume or area of favourable strata multiplied by a "yield factor", which represents either the average productivity of several basins, or a more specific figure based on a system of basin comparison and classification involving a wide range of individual geological factors, including the structural and depositional history, trap size and distribution, and the presence of source and reservoir rocks. This report, however, has estimated areas that might actually be underlain by oil and gas fields in each of the world's ocean regions and has assigned a concentrated hydrocarbon yield factor to these areas rather than to the various basins.

As reflected in table 1, the environment of deposition for source and reservoir rocks and the possibilities for structural and stratigraphic traps are thought to be most favourable in the sediments of the continental shelf and upper part of the continental slope. 8/ A thick sedimentary wedge, including turbidity sands deposited at the mouths of submarine canyons and in submarine fans, may underlie the continental rise in some areas, and geophysical surveys have identified structures in rise sediments similar to productive structures located beneath the continental shelf and slope.

Interesting are the numerous small ocean basins whose sediments may have a considerable thickness and overlie a continental or intermediate type crust. While their total area is only about 5.2 per cent of that of the major oceans, they may contain a volume of sediments of at least 10 per cent of that beneath the entire sea-bed. These include the Gulf of Mexico, Caribbean Sea, the Mediterranean, the Black Sea, Red Sea, South China Sea, Sea of Japan, the Sea of Okhotsk and the southern part of the Bering Sea. Their hydrocarbon potential is thought to be similar to, if not greater than, the continental rise, due to the increased opportunity for the deposition and preservation of petroleum source materials. Shallow seas, including the North Sea, the Adriatic, the East China, Kara, Laptev, East Siberian and Chukchi Seas, and the northern part of the Bering Sea are really continental shelf or "epeiric" seas, with depths that are already economically and technologically accessible, and as such are extremely important for their hydrocarbon potential.

The abyssal plains, which range in depth from about 5,000 to 7,000 metres, have not, in general, had the kind of depositional and post-depositional history favourable for petroleum generation and accumulation, even in modest quantities, much less in the quantities that would be required for any form of economic recovery. The environment of deposition and the great depth do not favour those areas as a source of important commercial supplies of petroleum. In addition, there is convincing world-wide evidence that temperature has had a primary influence on petroleum generation and that the optimum temperature has not everywhere been reached in sedimentary basins, particularly not in areas of low temperature gradient. Unfavourably low temperature conditions probably existed beneath the cold, stable main ocean basins and below much of the less deep bottoms during and following the deposition of the major volume of the sediments.

8/ The hydrocarbon potential of the lower slope and rise is quite controversial. While the experts contributing to the preparation of this report were rather pessimistic about prospects of the rise and lower slope, other authorities are quite optimistic (Peter A. Rona, K. O. Emery, M. Ewing, J. Ewing, E. Uchupi).

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Most deep ocean trenches and associated ridges are located adjacent to the convex sides of island areas or along tectonically active coastal margins such as that of the west coast of South America. Most trenches are in the Pacific Ocean; but a few exist also in the Atlantic and Indian Oceans respectively. The trenches include the deepest parts of the sea-bed and their floors are generally at depths greater than 8,000 metres. As some of the trenches and perhaps the associated ridges may include considerable thicknesses of sediment, they are considered to have some hydrocarbon potential in table 1 but the excessive depths preclude possibilities for exploitation in the foreseeable future.

The oceanic ridges rise above the abyssal plains of the major ocean basins and represent submarine mountain ranges formed by the welling up of volcanic rocks along major fracture zones where the sea-bed is rifting apart.

Since the oceanic ridges consist of volcanic rock with little sedimentary cover, the hydrocarbon potential of this physiographic province as well as that of the volcanic ridges and cones is considered to be negligible.

Table 1 gives the areas of the world's subsea physiographic provinces and estimates of the areas of each that are potentially prospective and productive of petroleum and concludes with estimates of ultimate potential recoverable barrels of oil, including equivalent gas. This table presents the results of many years of detailed world-wide study in a simplified and general form appropriate to a world report of this nature. As shown in table 1, the study arrived at an estimated world total of 2,272 billion barrels of ultimate potentially recoverable oil plus oil equivalent of the gas. 9/ It should be noted that in making this estimate it was assumed that all of this petroleum will be economically recoverable. This may not be found possible particularly with respect to the deeper water areas of lower average productivity. It must be emphasized that such estimates are, at best, speculative, and are based largely on industry experience in more mature areas having similar geological characteristics. The fact that the figures employed are relatively specific should not be interpreted as altering their speculative nature.

9/ Six thousand cubic feet of gas is assumed to be equivalent to one barrel of oil.

TABLE 1

Estimate of ultimate potential recoverable hydrocarbon b/ off-shore by physiographic provinces of the ocean floor

Physiographic Province	Area 10^6 sq km	Percent. of total	Group percentage	Prospective area: As percent. of physiog. province	Prospective area: Area in 10^6 sq km	Productive fields	Barrels per sq km	Ultimate potential recoverable petroleum b/ 10^9 barrels
Continental shelf (open ocean)	20.7	5.7		25.0	5.18	0.155	8,500,000	1,344
Continental slope (open ocean)	31.1	8.6		15.0	4.66	0.093	5,000,000	460
Continental rises (open ocean)	16.8	4.7	25.8	10.0	1.68	0.018	5,000,000	90
Shallow seas and small ocean basins (shelf, slope and rise)	19.0 a/	5.2		15.0	2.85	0.057	6,000,000	352
Trenches and associated ridges	6.0	1.6		10.0	0.6	0.005	5,000,000	26
Abyssal plains	138.4	38.2		0.0	0.0	0.0	0	0
Oceanic ridges and rises	119.0	32.9	74.2	0.0	0.0	0.0	0	0
Volcanic ridges and cones	11.0	3.1		0.0	0.0	0.0	0	0
TOTAL	362.0	100.0	100.0	4.1	14.97	0.328		2,272

a/ Including approximately 5×10^6 sq km of continental shelf in shallow seas.

b/ Figures include oil plus equivalent of the gas (6,000 cubic feet of gas equals one barrel of oil).

Source: Lewis G. Weeks, "Subsea Petroleum Resources", report prepared for the United Nations, April 1973.

TABLE 2

World subsea distribution of discovered and estimated ultimate potential petroleum*

Total Ocean Area: 362,000,000 sq. kilometres

Zone	Area 10^6 sq km	Physiographic province	Discovered to 1-1-1973	Estimated potential: Undiscovered**	Estimated potential: Ultimate	Remarks
Landward of 200 m. Isobath	21.90	Continental Shelf	167,481	1,376,519	1,544,000	Includes petroleum from shallow seas and small ocean basin shelves. See table 1.
Seaward of 200 m. Isobath	340.36	Some shelf, almost all slope, all rise and deep ocean basin	---****	728,000	728,000	
Landward of 3,000 m. Isobath	45.42	All Continental Shelf and slope, some rise	167,481	1,937,319	2,104,800	Includes petroleum from shallow seas and small ocean basin shelves and slopes. See table 1.
Seaward of 3,000 m. Isobath	318.15	Most rise, all deep ocean basin	---	167,200	167,200	
Landward of 40 miles from coast	15.66	Mostly continental shelf, some slope	147,454	1,202,546	1,350,000	Includes petroleum from shallow seas and small ocean basin shelves and slopes, where reached. See table 1.
Seaward of 40 miles from coast	346.87	Some shelf, most slope, all rise and deep ocean basin	20,027***	901,973	922,000	
Landward of 200 miles from coast	77.08	Most shelf and slope, some rise, and deep ocean basin, all small ocean basins	167,481	1,820,519	1,988,000	Includes petroleum from shallow seas and small ocean basin shelves, slopes, etc. as reached. See table 1.
Seaward of 200 miles from coast	288,04	Some shelf, slope and rise, most deep ocean basin	---	284,000	284,000	

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cubic feet equals one barrel of oil).

** Total estimated ultimately recoverable petroleum, 2,272 billion barrels of oil and oil equivalent of the gas (6,000 cubic feet of gas equals one barrel of oil). The figures assumed that all of this petroleum can be economically recovered.

*** This petroleum occurs in eastern North Atlantic (North Sea) and eastern Indian Ocean (Australia N.W. shelf). See tables A.3.2, A.3.10. In addition, minor fractions of the petroleum in the western North Atlantic (table A.3.1) in the western South Pacific (table A.3.7), and in the western Indian Ocean (table A.3.9) occur just seaward of 40 miles from the coast.

**** Does not include major reserves indicated in Santa Barbara Channel in water depths of 189-396 metres.

Source: Lewis G. Weeks, "Subsea Petroleum Resources", report prepared for the United Nations, April 1973.

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(c) Recovery potential

Forecasts of the size of potential petroleum resources are sometimes unduly optimistic, being based on questionable calculations and assumptions. In respect to the lower slope and continental rise, for which optimistic forecasts have been made, not only is the water depth great, but the best of any possible prospects probably lie deep within the lower part of thick sediments. Technology has yet to be developed and even then costs may be so high as to preclude developments of these lower sediments on a commercial scale for a long time.

Petroleum is a normal and widespread constituent of sediments, just as numerous minerals occur widely in the rocks of the earth crust. However, as is the case with these minerals, economic concentrations of petroleum occur in but a small percentage of the total world sedimentary area or sediment volume. If only those sedimentary basins which prove commercially productive are considered, the percentage of their total areal extent beneath which commercial petroleum will ultimately be found will in only limited instances approach 10 per cent; on a world-wide basis it will probably not average more than about 3 per cent.

Favourable deposition of the sediments and their subsequent history is far more important than the volume of sediments in determining the extent of petroleum occurrence. Thus, while hydrocarbons are normal constituents of nearly all sediments their availability varies from nil to several million barrels per cubic mile. In many basins exploration has had little or no success, despite decades of effort; in others some success has come after the drilling of scores, even hundreds, of wells; while in a few, success has come as early as the first well to be drilled.

The proportion of the provinces (see table 1) that may be considered a sedimentary basin may vary from less than 30 per cent to as much as 70 per cent of total. In turn, the proportion of the sedimentary basin area within which individual fields of petroleum may be scattered is considerably less, ranging to as low as 9 per cent.

While exploratory drilling below deep ocean waters may not present serious problems, completion and producing operations at great depths present serious still unanswered problems of engineering and economics. All estimates of potential petroleum resources below water depths greater than the maximum reached by current operations assume that engineering developments will enable them to be recovered economically.

The potential petroleum estimates in tables 1 and 2 which are themselves highly speculative, are based on the assumption that the cost economics will be everywhere similar to those for the continental shelf. The various percentages of areas that may prove productive are based on this assumption. Of the total estimated resources of 2,272 billion barrels, perhaps less than 25 per cent are in potentially highly productive areas.10/ The proportion of ultimately recoverable resources of areas other than the shelf which will in fact prove to be economically productive will depend on cost factors still to be determined.

Studies show that the costs of exploitation increase at an exceedingly rapid rate with increasing water depth; for example at 330 metres the cost will be at least four times higher than at 33 metres, where the cost is already twice that of an on-shore field of similar characteristics. Operations under 330 metres or more of water may be so costly that only giant fields will perhaps be profitably exploited. In some off-shore areas today, a 2,000 to 4,000 barrels a day well might be considered an uneconomic discovery. 11/ Distance from shore also influences the economic possibilities of developing off-shore fields, particularly in the case of natural gas, as there are no viable alternatives for transporting to shore installations other than by pipeline.

The disadvantages of water depth and distance can be partially offset by high productivity (i.e. output per well) and the size (i.e. total recovery) of the field. As an example, at 50 metres the technical cost of production from a 100,000 barrels daily field might vary from 28 to 35 U.S. cents according to the productivity of the wells (10,000 bbl/d or 3,000 bbl/d). For a 300,000 barrels daily field, the equivalent costs could be 15 to 21 U.S. cents per barrel.

It seems doubtful that petroleum in the yields required for commercial operations exists at depths of 3,000 metres and more, unless it be in very limited instances and as a result of a most exceptional or unique geological history. The cost involved in locating such fields alone would tend to be discouraging. On the other hand if petroleum should ever be found in a field of sufficiently large size, man will devise a means of commercial recovery. Since nothing can be considered a reserve or a resource unless it can be foreseen that it might be produced and used economically, the higher cost of off-shore operations precludes from resource status the many smaller or more costly to develop petroleum accumulations.

Reconnaissance seismic surveys are being conducted in water depths of at least 3,000 metres, and detailed surveys in depths of more than 1,000 metres in some cases. At present, seismic work can be carried out in very deep waters. Exploratory drilling with a view to establishing the presence of hydrocarbon as distinguished from general scientific purposes (with possibilities of re-entry)

10/ Weeks, L. states that 372 billion barrels of potential petroleum resources will be found in highly productive areas.

In a recent paper, Leuch and Masseron place total petroleum resources to 200 m. at 675 billion barrels, of which 155 billion are classified as proved or probable. (H. Le Leuch and J. Masseron, "Aspects économiques de la prospection et de l'exploitation des hydrocarbures en mer", Revue de l'Institut du Pétrole, April 1971).

11/ "Two contractors evaluate future of offshore drilling", Ocean industry, January 1973, p. 25.

has gone to depths of 500-550 metres. However, the deepest water in which a development well (with production facilities) has been completed, and was in operation by December 1972, is only 114 metres. Most of the world's off-shore production presently comes from areas under less than 30 metres of water.

Subsea platforms have been placed at depths of over 100 metres, and plans go forward for their use at depths approaching 300 metres or more of water. Within three to five years, off-shore oilfields at depths of up to 400 metres will be placed on production. The Santa Ynez field in the Santa Barbara Channel off California lies below water ranging from 189 to 396 metres in depth. The Forties field in the North Sea has water levels from 90 to 130 metres while water depths in the Brent field may go as deep as 150 metres. All three are giant fields, each with over one billion barrels of recoverable reserves. 12/

By the end of the present decade or in the 1980s, it should be feasible to complete development wells at depths of 600-1,000 metres. These depths correspond roughly to the upper part of the continental slope. The development of potential resources at depths from 200 to 1,000 metres will depend on the size of the field, the price of oil, the expenditures required and non-economic considerations.

However, it appears certain that costs will escalate rapidly. At levels of $US 5-7 per barrel, costs would be comparable with the cost of alternative sources of energy including tar sands, oil shales and coal hydrogenation and gasification. Thus, in the absence of major technological breakthroughs it is unlikely that potential hydrocarbon resources below, say, 1,500 metres would be developed during the present century. Nevertheless in the longer term such resources may well be economically significant.

3. Manganese nodules

(a) Geological nature of nodules

Manganese nodules occur relatively widely on the sea-bed. Generally they are found where the sedimentation rate is very low, so that most deposits occur below deep water and at substantial distances from the continents. Rarely they occur in shallow water close to the land, for example, in some sea-lochs in Scotland.

The nodules (and encrustations which do not appear to be economically significant) vary substantially in their composition, the principal elements present being iron, manganese, silica and lime in varying proportions. Their economic significance, however, is concentrated mainly on their nickel, copper and cobalt content. 13/

12/ Estimated reserves are: Santa Ynez, 3 billion barrels; Forties, 4.5 billion barrels, and Brent, over 1 billion barrels.

13/ Documents A/AC.138/36 and A/AC.138/73.

/...

(b) Characteristics of possible economic deposits

At the present stage of the development of systems to mine and recover metals from the nodules the criteria which will determine whether nodules are economically workable cannot be clearly defined. However, the main considerations will be:

(a) Nickel, copper and cobalt content,

(b) Their abundance, that is, the weight per unit area,

(c) The topography or physical relief of the sea-bed, and the nature of sea-bed sediments on which the nodules are lying,

(d) The chemical composition (possibility of impurities that might make processing more costly).

A considerable amount of information has been published about (a), although very sparse in relation to the total area involved, but little or no information on (b), (c) and (d) is available. The average grade of nodules that will be necessary to sustain a commercially feasible operation, and the cut-off grade, below which it would be uneconomical to mine, are unknown. However, information published by the enterprises that are examining these questions in some detail suggests that the first generation of mines will be based on nodules having at least an average of about 1.2 per cent nickel. 14/

In order to provide some indication of the economic significance in the context of this report, certain assumptions must be made:

(a) That the sampling is random and can therefore provide a basis for drawing generalized conclusions about the whole of the sea-bed;

(b) That individual samples are typical of the grade in the area from which they are obtained;

(c) That all the nodules are equally amenable to the extractive metallurgy processes being developed;

(d) That the nodules with grades falling within the arbitrary limit suggested above are present in sufficient quantity and over a large enough area to constitute a mine site;

14/ Some European industry sources have suggested that the mine sites of interest to them should have a combined nickel-copper content of at least 2.5 per cent. An American industry official suggested that a commercial mine site should have a content of over 2 per cent nickel equivalent based on expected future relative prices of Ni, Cu and Co: e.g., each 1 per cent of copper would be equivalent to 0.5 per cent of nickel, and 1 per cent cobalt = 1 per cent nickel (for instance, a nodule with 1.3 per cent Ni; 1 per cent Cu; 0.3 per cent Co = 2.1 per cent Ni equivalent).

/...

(e) That the physical relief of the sea-bed and details of the underlying sediments allow the operation of the mining systems likely to be used;

(f) That the chemical analyses of metal content accurately reflect nodule grades.

It must be strongly emphasized that these assumptions are made merely to provide an indication of the possible distribution of workable deposits: they would not be considered valid in a commercial assessment of resources.

The frequency with which nodules fall within different arbitrarily selected grade limits is shown in tables A.3.11 to A.3.25.

Despite extensive sampling of the sea-bed in less than 3,000 metres of water, only 69 analyses (14 per cent) refer to these depths, clearly indicating that nodules are significantly less abundant at these shallower depths. None of these analyses fall within the potential ore grade selected for this report, although one sample recovered from a depth of 90 metres off Argentina contains 1.1 per cent nickel and 0.8 per cent copper, suggesting that the possibility of at least second-generation mine sites being present below 200 metres cannot be entirely excluded.

No potentially ore-grade nodules were recovered from within 40 miles of land.

About 17 per cent of all the nodules containing more than 1.2 per cent nickel, - but only 10 per cent of the nodules containing at least 1.2 per cent nickel and 0.8 per cent copper, - were found within 200 nautical miles of land.

TABLE 3

High-grade nodules in the Pacific, Atlantic and Indian Oceans

Ocean	Number of stations	With at least 2% combined Ni and Cu		With at least 2% combined Ni and Cu including at least 1.2% Ni		Less than 2.0% combined Ni and Cu but at least 1.2% Ni		At least 1.0% each of Ni and Cu		Number of stations deeper than 3,000 metres
		No.	%	No.	%	No.	%	No.	%	
North Pacific . . .	209	49(2)	23	32(2)	15	5(5)	2 1/2	34	16	27
South Pacific . . . (140°E to 70°W)	150	20(4)	13	16(3)	11	5	3	7	5	15
North Atlantic. . .	35	0	-	0	-	1	3	0	-	10
South Atlantic. . . (70°W to 20°E)	40	0	-	0	-	1	2 1/2	0	-	10
North Indian . . .	6	0	-	0	-	1	1 1/2	0	-	2
South Indian . . . (20°E to 140°E)	48	1	2	1	2	3(1)	6	0	-	5
Totals	478	70(6)	14	49(5)	10	16(6)	3	41	8	69

Data derived from Horn, Delach and Horn, 1973.

Figures in brackets relate to stations within 200 nautical miles of coasts.

/...

(c) Geographical distribution of deposits

Although it is alleged that a great number of samples of manganese nodules have been collected and analysed by commercial companies, all publicly known information about the distribution and metal content of nodules is based on approximately 600 samples. The latest data on ocean manganese nodules and their metal value have been summarized by D. R. Horn, M. N. Delach and B. M. Horn 15/ and Frazier and Arrhenius. 16/

Review of world-wide distribution of manganese nodules shows that there are provinces of nodules in the Atlantic and Indian Oceans, but the most extensive deposits are located in the Pacific Ocean.

In the North Atlantic nodules appear to be concentrated (fig. II) on the Blake Plateau (in water depths of about 1,000 metres) and in the red clay area, 1,100 miles east of Florida; encrustations occur in the Mid-Atlantic Ridge (fig. II). Although in some places nodules have rather high density, they are generally characterized by low metal content (Ni 0.18-0.52 per cent, Cu 0.08-0.29 per cent, Mn 13.9-14.5 per cent, Co 0.35-0.42 per cent) and some include substantial quantities of carbonate material unfavourable for metallurgical processing.

In the South Atlantic there are some localities of thick crusts and nodules, again generally with low metal content. For instance, the nodules on the Rio Grande Rise off the east coast of South America contain up to 0.14 per cent Ni and 0.09 per cent Cu. Off the west coast and southward of South Africa there have been recorded extensive areas of manganese nodules and crusts, but the metal content there appears to be low (Ni 0.67 per cent, Cu 0.16 per cent).

In the Indian Ocean there are several areas of nodules and crusts, e.g. the Agulhas Plateau deposit which is located in water about 3,000 metres deep. In some regions of the Indian Ocean, such as the Madagascar Basin and Crozet Basin, manganese nodules form extensive fields, but the metal content is also generally low, with grades similar to those in the Atlantic Ocean and ranging Ni 0.24-0.83 per cent, Cu 0.12-0.15 per cent. Industry sources have indicated however that some potentially mineable nodule deposits have been discovered in the Indian Ocean.

It is worth noting that the Atlantic and Indian Oceans tend to have relatively high rates of sedimentation and are characterized by considerable quantities of continental debris, adversely affecting geological environments for metal accumulation in nodules.

15/ D. R. Horn, M. N. Delach and B. M. Horn "Metal Content of Ferromanganese Deposits of the Oceans", 1973, Technical Report No. 3 NSF-GX 33616. D. R. Horn, B. M. Horn and M. N. Delach "Ocean Manganese Deposits, Metal Values and Mining Sites", unpublished manuscript, 1973, Technical Report No. 4, NSF-GX 33616.

16/ J. Z. Frazier and G. Arrhenius, "World-wide Distribution of Ferromanganese Nodules and Element Concentration in Selected Pacific Ocean Nodules", Technical Report No. 2 NSF-GX 34659, October 1972.

In the South Pacific numerous nodule deposits are reported, many of which are concentrated on or close to submarine elevations such as the Manihiki Plateau, Tuamotu Plateau, the Line Islands, Cook Islands and Society Islands. Average values for metals contained in nodules on such elevations are Ni 0.41 per cent, Cu 0.13 per cent, Mn 14.6 per cent, Co 0.78 per cent, whereas on the abyssal plain average values are Ni 0.51 per cent, Cu 0.23 per cent, Mn 15.1 per cent, Co 0.34 per cent. It has been suggested that there are several mine-grade nodule deposits in the South Pacific. Generally they are not as extensive as those in the North Pacific, and some have very high cobalt content.

In the North Pacific concentrations of nodules with higher metal value are extensive. In addition to slow and continuous sedimentation and very little continental debris, the geological environmental conditions also appear more favourable owing to the absence of large oceanic ridges and little sedimentation of carbonate material. The North Pacific floor may be split into two types: a red clay and siliceous ooze. Although both contain manganese nodules, the greater concentration of nodules and the more extensive deposits occur where there is a siliceous ooze floor. Moreover, according to the samples available for analysis, the nickel and copper content of these nodules is higher than in nodules from the red clays. The average metal values of nodules from the siliceous deposits are Ni 1.28 per cent, Cu 1.16 per cent, Mn 24.6 per cent and Co 0.23 per cent, while the nodules from the red clays contain Ni 0.76 per cent, Cu 0.49 per cent, Mn 18.2 per cent and Co 0.25 per cent. Most Ni-rich nodules in the siliceous ooze region are located in water depths 4,000-5,000 metres.

The nodules with highest values of Ni and Cu lie in an east-west belt between 6^{o}N and 20^{o}N latitude and extending between 110^{o}W and 180^{o}W longitude.

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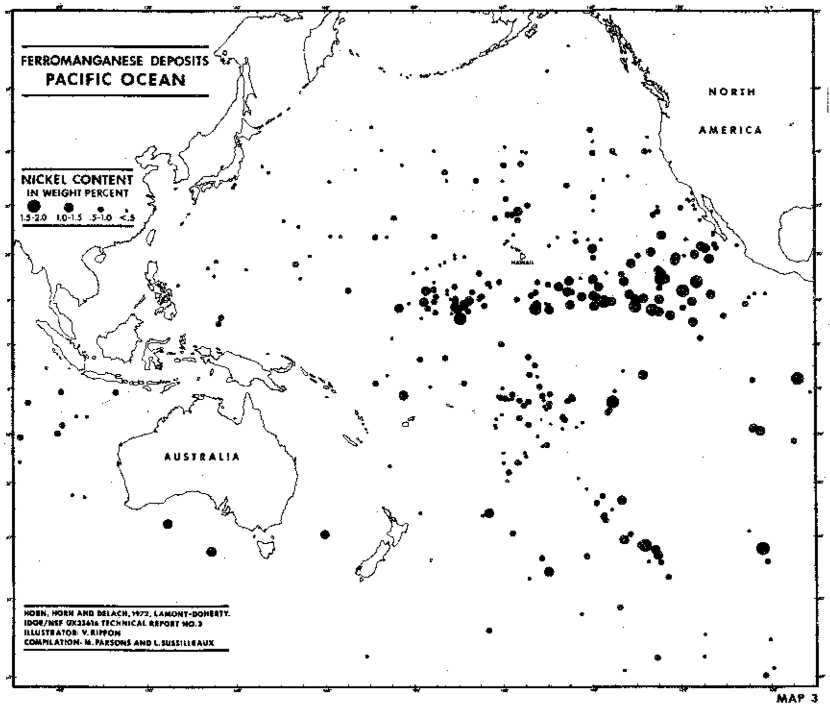
Figure II Major provinces of manganese nodules on the ocean floor (after D. R. Horn, B. M. Horn and M. N. Delach, unpublished manuscript, 1973, Technical Report No. 4, NSF-GX 33616) 1- the Blake Plateau; 2- the Red Clay area east of Florida; 3- the Mid-Atlantic Ridge 4- the Rio-Grande Rise; 5- the Agulhas Plateau; 6- the Madagascar Basin; 7- the Crozet Basin; 8- the Manihiki Plateau; 9- the North Pacific Belt.



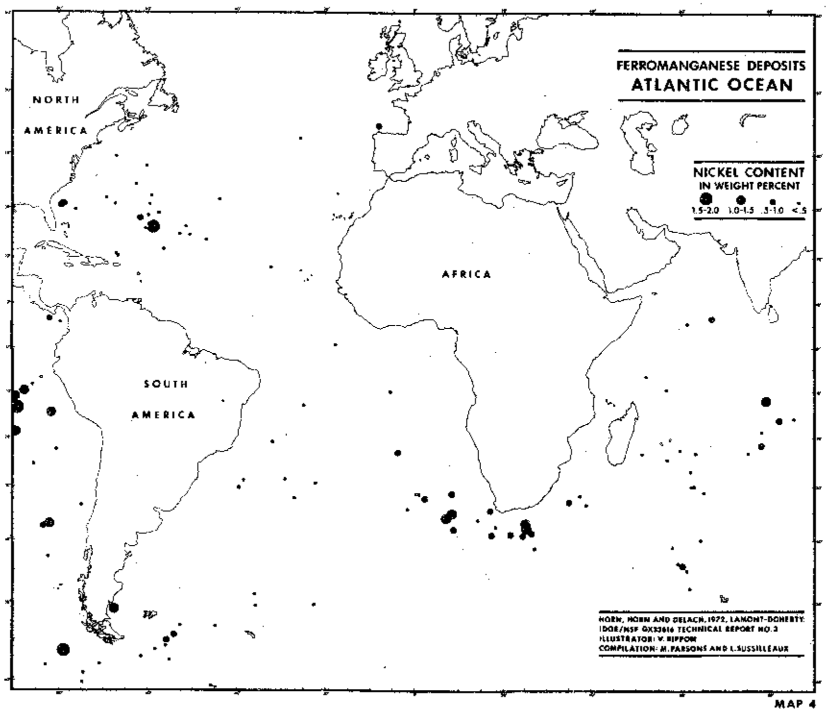


Figure III Nickel values obtained from ocean ferromanganese deposits. As was true of copper, high nickel values are confined to an area of the south-east and south-central North Pacific (from D. R. Horn, B. M. Horn and M. N. Delach, unpublished manuscript, 1973, Technical Report No. 4, NSF-GX 33616).

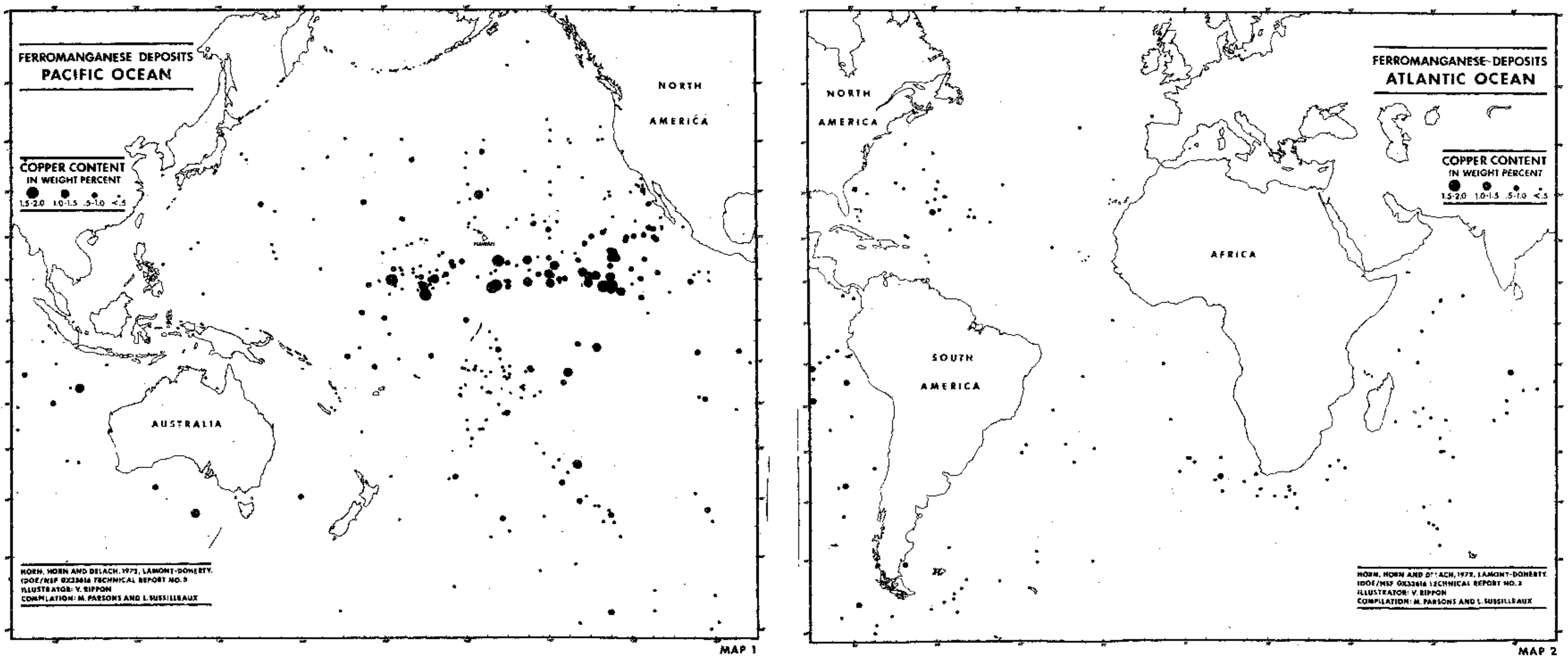


Figure IV Copper values obtained from ferromanganese deposits of the world ocean. Highest concentrations are confined to an area of the south-east and south-central North Pacific (from D. R. Horn, B. M. Horn and M. N. Delach, unpublished manuscript, 1973, Technical Report No. 4, NSF-GX 33616).

4. Other minerals

These resources can be subdivided into four main categories. The first category covers minerals that can be extracted from sea water. As far as can be foreseen, in practical, economic terms only common salt, magnesium (as the oxide, magnesia, principally used in refractories and as the metal, obtained from magnesia) bromine and, possibly, uranium are likely to be of interest. However, for the purposes of this study they need not be considered further as, like present production facilities, future developments seem certain to use coastal plants, the sea water being obtained from at most a few hundred metres from the shore.

The second category embraces all the minerals present in unconsolidated deposits on the sea-bed, the third includes mineral deposits within the consolidated rocks under the sea-bed and the fourth is represented by metalliferous muds and brines.

(a) Unconsolidated deposits

Of the seven minerals other than hydrocarbons currently being recovered from the sea-bed, four are found in unconsolidated deposits: sand and gravel (for convenience considered as a single mineral); calcium carbonate in various forms; tin-bearing sands; and magnetite (iron) sands.

Sand and gravel

The quantity and value of marine-dredged sand and gravel is greater than any other solid mineral currently being won from the sea-bed: the value in 1970 has been estimated at about $100 million. Production is highest in those countries where land sources close to major markets are becoming exhausted or closed for mining because of competing demands for the land in question.

The commercial feasibility of exploiting marine deposits of this very low-priced commodity is closely related to transport costs. Marine aggregates are competitive only if they are dredged relatively close to their markets and also can be landed for delivery within a closer radius than land sand and gravel supplies. Water depth also influences costs: at present the maximum depth is probably about 30 to 35 metres, although this is likely to increase to, perhaps, 50 metres within the next decade.

The growth in the marine sand and gravel industry that has taken place the last few years is likely to continue. However, it is difficult to predict how far increasing demand and growing shortages of conveniently located deposits on land, particularly of gravel, will lead to the development of marine deposits substantially further from land, below considerably deeper water, or off other coasts. It seems reasonable to assume that dredging for sand and gravel will never be carried out below 200 metres of water and is unlikely to extend more than 40 miles from the coast for many years.

TABLE 4

Output and value of the marine mining industry, 1970

Commodity	Production: Quantity '000 tons	Production: Value $US million	Percentage of total off-shore production by value	Estimated percentage of world production
Sand and gravel . . .	55,000	100	48	1.0
Tin	12.5	41	19	5.8
Calcium carbonate . .	18,800	36	17	1.0
Sulphur	1,000	26	13	2.4
Iron sands	n.a.	4	2	1.0
Barytes	122	1	1	3.5
Diamonds	16,571 carats	n.a.	-	1.0
Total. .		208	100	

Sources: A. A. Archer "Progress and Prospects of Marine Mining", in 1973 Offshore Technology Conference, Reprints, vol. 1, p. 321; and Marine Science Affairs, 1970: Annual Report of the President to the Congress on Marine Resources and Engineering Developments, p. 67.

Calcium carbonate

Calcium carbonate, in the form of aragonite sands and muds produced by natural precipitation from sea water, shells and shell sands, is currently being dredged for a variety of uses, including the manufacture of cement and agricultural lime. The value of off-shore production in 1970 has been estimated at $35.5 million. Exploitation is usually carried out in very shallow water and near to land, although the very large resources of high-grade aragonite deposits on the Bahamas Banks have led to the creation of an artificial island and harbour.

These are low-value materials, and commerical exploitation of deposits on the sea-bed is therefore limited by economic constraints similar to those that apply to sand and gravel. Except for shells used as aggregate, the alternative material on land is limestone, and this occurs in many forms, common in many parts of the world. It follows that sea-bed resources are likely to be recovered only where the locally prevailing economic conditions are favourable, and within the same ranges of depth and distance from shore as apply to sand and gravel.

Heavy-mineral placers

These are deposits in which a wide range of minerals occur as heavier grains in alluvial deposits. Those most likely to be of economic importance are tin, gold, platinum, rutile and ilmenite (both important sources of titanium), magnetite (a form of high-grade iron ore particularly valuable for some purposes), together with diamonds, monazite (an important source of some of the "rare earth" minerals), zircon (the principal source of zirconium metal, but also used as a refractory sand) and possibly chromite (another important refractory, as well as the source of chromium metal).

Sorting, dilution and attrition of the heavier of these minerals during their transport by water lead to a relatively rapid decrease in their concentration away from the rocks from which they are derived. For example, half of the economically workable placer deposits of tin and gold are probably within 5 and 10 miles, respectively, of their sources: thus even where the source rocks are close to the coast, exploitable deposits are not likely to be present much farther off shore. The lighter heavy minerals (including rutile, ilmenite, monazite and zircon) may be transported much greater distances. However, the distribution of economically workable deposits is likely to be limited to present or old submerged beaches relatively near to the shore and below shallow water, as the wave energy required to concentrate these minerals is normally available only on beaches.

Alluvial deposits on land and in estuaries, and present and old raised beaches, are currently very important sources of several placer minerals. The dredging of similar deposits off shore is on a much more limited scale, being limited to the recovery of tin off Thailand and Indonesia and of magnetite off Japan and the Philippines: current total annual value is estimated to be about $42 million.

Off-shore resources, particularly of tin, are likely to be exploited on an increasing scale in the future. However, in general, they are likely to be economically important only within 40 miles of coasts and under water less than 200 metres deep.

Phosphorite

Encrustations, nodules, sands and muds containing varying amounts of calcium phosphate are known to exist on the sea-bed in several parts of the world, below water varying in depth from substantially less than 200 metres to more than 3,000 metres, and up to 200 miles or more from the coast. The grade of these deposits, recorded as their P_2O_5 (phosphorous pentoxide) content, is variable but is generally below the grade at which deposits of phosphate rock on land are usually considered to be uneconomical to work. The nature of the impurities also has a bearing on the value of marine phosphates.

Reserves of phosphate rock on land are very large, although limited to a relatively small number of areas. Being a relatively low-cost mineral, transport costs usually account for a substantial proportion of delivered prices, so that local marine phosphorite deposits of comparable grade could absorb the higher mining costs that are likely to be associated with their exploitation. Nevertheless, marine mining, if proved economically feasible in the future, is likely to be restricted to large, high-grade deposits in water less than 200 metres deep and within 40 miles of coasts. Phosphate sands and muds, which may cost less to process and which might be used directly as fertilizers, may prove economically important, particularly in developing countries far from existing land sources.

Barite

Nodules and sands containing barite (or barytes: barium sulphate, for which there are a variety of uses including, for example, as an additive to drilling muds), are known to be present on the sea-bed in a few areas. Exceptionally these may contain up to 75 per cent of barite. It seems unlikely that deposits will be found that are large enough and of sufficiently high grade to be competitive with sources on land, except perhaps in shallow off-shore waters.

(b) Consolidated deposits

Underground mining

At present a few minerals are exploited below the sea-bed by conventional underground mining, by far the most important being coal. Access is gained from shafts on land, although ventilation may also be provided by shafts constructed in artificial islands. This means is feasible only in very shallow water, and can be used for a number of minerals up to a maximum distance of perhaps five miles from land.

/...

The mining of ores beneath the sea-bed without gaining access from land would depend on the development of new, very advanced, technology to enable shafts to be sunk in the deep sea-bed, men, materials and the ore being transferred, for example, by submersible vehicles or by extending the shafts to the surface of the sea. At this stage, such possibilities appear to be remote for the foreseeable future.

Opencast mining

Opencast mining of consolidated (or hard) rocks on the surface of the sea-bed has recently been carried out in very shallow water off Alaska, where barite has been won by blasting followed by dredging. The commercial success of this operation in a generally unfavourable environment suggests that this method might be applied to other minerals elsewhere, if the locally prevailing economic circumstances are favourable. This seems likely to be the case only in water less than 200 metres deep and relatively close to land.

Although consolidated rocks similar to those that are successfully mined on land are known to occur on the deep sea-bed, for example as ores of copper (probably related to the boundaries of diverging continental plates during the process of sea-floor spreading), and chromium, the prospect of commercially viable opencast mining at depths such as those of oceanic ridges and rises would seem very doubtful.

Solution mining

Some minerals can be won as liquids, either in solution or molten. Salt and potash-bearing minerals are currently being recovered in solution through boreholes on land.

Molten sulphur is recovered by the Frasch process in which steam is injected into the sulphur-bearing beds to melt the sulphur.

In recent years the abundant availability of sulphur recovered from natural gas and, to a lesser extent, petroleum, has inhibited the development of new Frasch facilities. However, in the long term there is likely to be renewed interest in the Frasch process both on land and off shore because of increasing demand for sulphur (which is closely related to the demand for fertilizers) and, perhaps, an eventual decrease in the amount of sulphur available from hydrocarbons. Off-shore installations, like those off the Gulf coast of the United States of America, are likely to be limited to shallow water within 40 miles of the coast.

(c) Metalliferous muds and brines

Several basins have been found within the central rift valley of the Red Sea at water depths of 1,900 to 2,200 metres containing mineralized muds and hot brines which may be economically workable. Most of the present metals are found as sulphide minerals disseminated throughout the sediments. In the largest of the basins explored (by coring), the Atlantis II Deep, the upper 10 metres are estimated to contain over 50 million tons of fine-grained metalliferous sediments with average metal content of 3.4 per cent zinc, 1.3 per cent copper, 0.1 per cent lead, 0.005 per cent silver and 0.00005 per cent gold. The deposits are saturated with, and overlain by, hot salty brines up to 200 metres thick which contain the same heavy metals in concentrations 1,000 to 50,000 times higher than in normal sea water. These brines are considered to be the hydrothermal solutions which have precipitated the minerals within the muds. It is thought that sea water percolates downwards along the rift zone, which is the boundary of two major crustal plates, becomes heated and charged with minerals from volcanic sources or dissolved from adjacent rocks, and then emanates upwards to mineralize the overlying unconsolidated sediments.

It is reported that research efforts are under way with a view to developing techniques for extraction of the minerals contained in the hot brines. However, no information is available on these tentative first steps.

Similarly, metal-enriched sediments are known to exist elsewhere in the deep ocean, for example at other sites of crustal-plate divergence or sea-floor spreading, at the crest of the East Pacific Rise and in the axial valley of the Mid-Atlantic Ridge. Concentrations of valuable metals found in places other than the Red Sea rift have not been sufficiently high to be of commercial interest, and mining and transportation costs in these distant off-shore areas would be prohibitively high. Even if deposits with concentrations much higher than those found to date were to be discovered in deep oceanic ridges and rifts, they would probably not be exploited within the next few decades.

II. ECONOMIC SIGNIFICANCE OF SEA-BED RESOURCES, ACCORDING TO SOME PROPOSED LIMITS FOR NATIONAL JURISDICTION

As stated in the introduction to this report, the four main limits studied are: 40 nautical miles, 200 metre isobath, 3,000 metre isobath and 200 nautical miles. Thus, the assessments made on the basis of available data and information are further categorized, pursuant to General Assembly resolutions 3029 B and C (XXVII), according to the areas seaward and landward of each limit:

(SEAWARD) - THE INTERNATIONAL AREA (General Assembly resolution 3029 B (XXVII))	(LANDWARD) - COASTAL STATES (General Assembly resolution 3029 C (XXVII))

40 nautical miles

(Seaward)

Area: 346.87×10^6 sq km. It comprises some of the shelf (including a portion in less than 200 metres of water), most of the slope and all of the rise and beyond, including the small ocean basins. In some areas the shelf extends far beyond the 40-nautical-mile limit, for example, in the Arctic and Bering Sea, off Australia, the south-eastern part of South America, the north-eastern part of North America, and South-East Asia.

Hydrocarbons: Major reserves of petroleum have already been proved beyond the 40-nautical-mile limit below less than 200 metres of water in a number of sedimentary basins of the continental shelf. The geological and economic possibilities of the slope, rise and beyond are discussed under the area seaward of 200 nautical miles. Total proved hydrocarbon reserves (all on the continental shelf) amount to 20 billion barrels. Estimated ultimate potential resource is 922 billion barrels, 41 per cent of total off-shore resources.

(Landward)

Area: 15.66×10^6 sq km. It is made up mostly of continental shelf but does include a portion of the slope in some regions, such as the west coast of North and South America.

Hydrocarbons: Over 90 per cent of the world's proved off-shore reserves, estimated at 147.5 billion barrels of oil equivalent (oil and natural gas), occur within this area. It has received the greatest attention both because of economic considerations and because some in-shore areas are extensions of on-shore producing regions. Ultimate potential hydrocarbon resources have been estimated at 1,350 billion barrels of oil equivalent, which represents 59 per cent of total sea-bed hydrocarbon resources.

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(SEAWARD) - THE INTERNATIONAL AREA (General Assembly resolution 3029 B (XXVII))	(LANDWARD) - COASTAL STATES (General Assembly resolution 3029 C (XXVII))

40 nautical miles (continued)

Manganese nodules: All known mine-grade nodules of the deep sea basin occur within this zone.

Manganese nodules: No known mine-grade nodules occur within these limits. Concentrations of low-grade nodules are known in some places in shallow water close to land, e.g. some sea-lochs of Scotland.

Other minerals: In the foreseeable future, few mineral deposits are likely to be exploited more than 40 miles from the coast, even where the water is substantially less than 200 metres deep. It is possible, however, that eventually dredging of phosphorites and perhaps placer deposits on the outer part of the continental shelf, and phosphorites on the continental slope may take place in this area. Metalliferous brines and muds and other metal deposits on the sea-bed are likely to be within this area.

Other minerals: In the shallower parts of the continental shelf, increased exploitation of sand and gravel, calcium carbonate in several forms, and tin can be expected. Commercial exploitation of other placer deposits, particularly of rutile and ilmenite, but possibly also of gold, platinum, zircon and monazite, and the extension of submarine opencast mining for a number of minerals, may become commercially feasible within the next decade. In the longer term off-shore deposits of sulphur may become of increasing importance and higher grade phosphorite deposits may be exploited for local use.

200 metre isobath

Area: 340.36×10^6 sq km. This area covers some of the shelf, notably in high northern latitudes, almost all of the slope, and all of the rise, abyssal plain and other features of the ocean basin, including the small ocean basins.

Area: 21.90×10^6 sq km. It is made up almost entirely of continental shelf, but does not necessarily include all of the shelf.

Hydrocarbons: Since this area includes a portion of the continental shelf and almost all of the upper part of the slope, it presents favourable conditions for hydrocarbon potential, and, indeed, more than 1 billion barrels of oil have already been

Hydrocarbons: The area contains almost all the proved reserves, approximately 167.5 billion barrels, and the greater part of the ultimate potential resources, about 68 per cent of the total potential for the sea-bed or 1,544 billion barrels.

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(SEAWARD) - THE INTERNATIONAL AREA (General Assembly resolution 3029 B (XXVII))	(LANDWARD) - COASTAL STATES (General Assembly resolution 3029 C (XXVII))

200 metre isobath (continued)

Hydrocarbons (continued): discovered within this zone, in the Santa Barbara Channel off California. The upper part of the slope includes areas favourable for hydrocarbon generation and entrapment. However, the economic feasibility of developing the upper slope is less than that of the shelf in the same geographical and geological areas owing to the greater depth of the water. The lower part of slope, the rise and areas beyond are reviewed below under the 200 nautical mile and 3,000 metre isobath limits. Total estimated ultimate hydrocarbon resources beyond 200 metres are 728 billion barrels, that is 32 per cent of the estimated total off-shore hydrocarbon resources.	
Manganese nodules: All known mine-grade nodules occur within this zone.	Manganese nodules: No known mine-grade nodules occur within this zone. The very few concentrations of nodules in shallow water are too low in marketable metal content to be of economic interest, although the sample taken in 90 metres of water off Argentina cannot rule out the possibility of commercially valuable concentrations.
Other minerals: There may be a potential for the future development of phosphorites on the continental slope, and possible metalliferous muds and brines and other metallic deposits associated with oceanic ridges.	Other minerals: The minerals listed above for the 40-nautical-mile area may occur on the continental shelf landward of 200 metres. However, in the next few decades, few mineral deposits are likely to be exploited more than 40 miles from the coast, even where the water is substantially less than 200 metres deep. In some areas, the cost of dredging some distance from the shore may be substantially higher than in sheltered coastal waters, as more time may be lost due to rough seas.

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(SEAWARD) - THE INTERNATIONAL AREA (General Assembly resolution 3029 B (XXVII))	(LANDWARD) - COASTAL STATES (General Assembly resolution 3029 C (XXVII))
3,000 metre isobath	
Area: 318.15×10^6 sq km. It includes the lower part of most continental slopes, most of the continental rise and all of the abyssal plain and other features of the deep ocean basin, and the deeper portions of small ocean basins.	Area: 45.42×10^6 sq km. It comprises the entire continental shelf and most of the slope. In some cases it may include the upper part of the rise and almost all the small ocean basins.
Hydrocarbons: The only hydrocarbon potential would be beneath the lower continental slope, the rise, and in small ocean basins. The geological uncertainties and economic considerations of hydrocarbon recovery from these areas are discussed under the 200 mile limit. The hydrocarbon potential of the area is estimated to be 7 per cent of total off-shore resources, that is, 167 billion barrels (table 1).	Hydrocarbons: This area includes all the proved petroleum reserves and 93 per cent of the potential hydrocarbon resources. The potential of the slope is subject to some controversy: some contend that the potential is higher than that of the shelf; others believe the hydrocarbon possibilities are non-existent for all practical purposes. A significant portion of the small ocean basins included within the 3,000 metre limit may contain hydrocarbon resources, as they have thick sedimentary sections.
Manganese nodules: Most mine-grade nodules are likely to be found within this zone, including all of the favourable nodule belt of the North Pacific Ocean.	Manganese nodules: Manganese nodules have been found in many places in depths of less than 3,000 metres, although they appear to be less abundant and contain low values of copper and nickel.
Other minerals: Metalliferous muds and brines might possibly be found in rift zones of oceanic ridges, but their economic potential is questionable. Another possibility might be deposits of copper and other metals in mineralized portions of oceanic ridges, indications of which have been provided by the JOIDES boreholes. However, the prospect of commercially viable opencast mining beneath deep water within the foreseeable future appears to be very doubtful.	Other minerals: The minerals listed above for the area landward of 40 nautical miles occur in this area also and may be expected to be exploited in the near future. The area also includes the best known occurrence of metalliferous muds and brines in the Red Sea. Most off-shore potential resources of phosphorite fall within this zone, since they occur mostly on the continental slope in water depths of less than 3,000 metres.

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(SEAWARD) - THE INTERNATIONAL AREA (General Assembly resolution 3029 B (XXVII))	(LANDWARD) - COASTAL STATES (General Assembly resolution 3029 C (XXVII))

200 nautical miles

Area: 288.04×10^6 sq km. It comprises a very small portion of the continental shelf, some of the slope, most of the rise and most of the deep ocean basin and its various physiographic features.	Area: 77.08×10^6 sq km. It includes the greater part of the continental shelf, most of the slope, some of the rise and a part of the deep ocean basin and almost all small ocean basins.
Hydrocarbons: The most promising areas for hydrocarbons are the remaining part of the continental shelf, about 250,000 square kilometres, and the upper part of the remaining slope. It should be noted that a considerable portion of the shelf and slope is located within high northern latitudes, where appropriate technology has yet to be developed. There may be hydrocarbon potential in the lower part of the slope and the rise, but again, there are differing opinions as to its potential, some contending that the potential of the slope and rise is the same or higher than that of the shelf, others holding that there is virtually no hydrocarbon potential there. In view of the great depths of most of these areas, the economic possibilities of recovering hydrocarbons are considered to be remote. On the basis of present knowledge, the hydrocarbon potential of the abyssal plains and other parts of the deep ocean basin is considered to be negligible from both geological and economic viewpoints. Total ultimate hydrocarbon resources of the area seaward of 200 nautical miles are estimated to be equivalent to approximately 284 billion barrels of oil or 13 per cent of total off-shore resources (table 1).	Hydrocarbons: Since this area excludes some of the continental shelf and slope, the potential for hydrocarbon resources is not as great as that for the 3,000-metre limit although the total area is much larger. All of the proved reserves to date fall within the 200-mile limit. The potential of the slope is dealt with above. Total resources are estimated to be approximately 1,988 billion barrels or 87 per cent of the estimated total resources of hydrocarbons of the sea-bed.

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(SEAWARD) - THE INTERNATIONAL AREA (General Assembly resolution 3029 B (XXVII))	(LANDWARD) - COASTAL STATES (General Assembly resolution 3029 C (XXVII))

200 nautical miles (continued)

Manganese nodules: Most but not all mine-grade nodules, including all of the most favourable mine sites identified in the North Pacific Ocean fall within this zone.	Manganese nodules: Since this zone includes a part of the deep ocean basin, particularly around small volcanic islands and archipelagos and the area off the west coast of North and South America, there is potential for commercial mining. About 10 per cent of possible mine-grade samples, according to up-to-date published information, fall within this zone, nearly all in the Pacific.
Other minerals: In the foreseeable future, no mineral deposits are likely to be exploited so far from the coast, even on the small portion of the continental shelf beyond 200 miles. There is a possibility, however, that dredging of phosphorites on and beyond the shelf may eventually be carried out. The rift zones of oceanic ridges are believed to contain metalliferous muds and brines.	Other minerals: All of the presently exploitable mineral resources and most of those having potential economic value in the next several decades are located within this zone. These include all sand and gravel, calcium carbonate, various placer deposits, opencast mine sites on the continental shelf, most phosphorite deposits and metalliferous brines and muds in the Red Sea. Some parts of oceanic ridges with possible mineral potential come within the 200-mile zone along the west coast of North America and in the northern part of the Indian and Atlantic Oceans.

TABLE 5

Summary - Economic significance of sea-bed resources according to various proposals on limits of national jurisdiction

	INTERNATIONAL AREA	COASTAL STATES
40 nautical miles from coast	Area: 346.87×10^6 sq km	Area: 15.66×10^6 sq km
Hydrocarbons -	41 per cent of total ultimate resources, including 20 billion barrels already discovered to date	- 59 per cent of total ultimate reserves, including 90 per cent of proved reserves
Manganese nodules	All known mine-grade deposits	No known mine-grade deposits
Other minerals	Some near-term prospects, including Red Sea metalliferous muds and brines	All immediate prospects and most in foreseeable future
200 metre isobath	Area: 340.36×10^6 sq km	Area: 21.90×10^6 sq km
Hydrocarbons -	32 per cent of total ultimate resources, including some reserves discovered to date; near-term prospects on outer shelf and upper slope	- 68 per cent of total ultimate resources, including 167.5 billion barrels proved (almost all reserves discovered to date)
Manganese nodules	All known mine-grade deposits	No known mine-grade deposits
Other minerals	Possible near-term prospects in metalliferous muds and brines of Red Sea rift. No other prospects in foreseeable future	Immediate prospects and almost all in foreseeable future
3,000 metre isobath	Area: 318.15×10^6 sq km	Area: 45.42×10^6 sq km
Hydrocarbons -	only 7 per cent of total ultimate resources; some long-term prospects in continental rise and deeper parts of small ocean basins	- 93 per cent of total ultimate resources, including <u>all</u> of proved reserves and immediate prospects
Manganese nodules	All known mine-grade deposits	No known mine-grade deposits
Other minerals	No prospects in foreseeable future	All immediate prospects and all in foreseeable future
200 nautical miles from coast	Area: 288.04×10^6 sq km	Area: 77.08×10^6 sq km
Hydrocarbons -	only 13 per cent of total ultimate resources; long-term prospects in continental rise	- 87 per cent of total ultimate resources, including <u>all</u> of proved reserves and most immediate prospects
Manganese nodules	Most known mine-grade deposits	Some mine sites adjacent to volcanic islands in the North and South Pacific
Other minerals	No prospects in foreseeable future	All immediate prospects and all in foreseeable future

ANNEX I

REPLIES OF GOVERNMENTS, UNITED NATIONS BODIES AND SPECIALIZED AGENCIES

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ARGENTINA

/Original: Spanish/
9 April 1973

1. INTRODUCTION

The development of undersea mining activities in Argentina has been slight, not to say insignificant. The evaluation of Argentina's mineral resources, except for petroleum, has only begun. A large amount of useful information for the evaluation of the petroleum potential of Argentina's continental shelf has been obtained in connexion with undersea geophysical studies.

The main activity undertaken up to the present time is the geological and geophysical scientific investigation of the coast and the sea-bed, which constitutes the initial contribution to the evaluation of undersea mineral resources.

This study also includes scientific and mining research. A basic inventory covering coastal studies and undersea studies of the continental shelf and the deep sea has been drawn up and may be added to the bibliography cited in the text.

2. COASTAL STUDIES

Coastal studies have been carried out chiefly by the Naval Hydrography Service.

The most important studies include those of the River Plate General Survey Commission (Comisión de levantamiento integral del Río de la Plata) (CLIAP), the Naval Hydrography Service (1963), Capurro (1965), Ottman and Urien (1965) and Urien (1966 and 1967). These publications contain the most salient features of the results obtained through the implementation of the General Survey Plan.

There are also references to be found in scientific and technical studies of a mining-geology nature. In the Evaluation of Mineral Resources by the Federal Investment Council (1963) there are some references to the minerals of the coastal zones: the possibility of exploiting the ferruginous sands of Buenos Aires Province (Lannefors, 1929). The work of Cortelezzi (1960) on the opaque minerals of the Atlantic coast sands should also be mentioned.

The few subsequent mineralogical studies relate to heavy minerals; mention should be made of studies of the sands of the Bay of San Blas in Buenos Aires Province, carried out by Angelleli and Chaar (1964 and 1967), because of their high titano-magnetite, ilmenite and zircon content, and the "Studies of the Sands of the Coast of Buenos Aires between Bahía Blanca and Río Negro" by Terrugi et al. (1964). Calculations of the reserves of ferrotitaniferous mineral in the Bay of San Blas (Novarini, 1955) indicate their possible future economic importance.

It might be inferred that there are probably high concentrations of heavy minerals in submerged placers of the Argentine continental shelf. This confirms the views of specialists concerning the need for evaluation of Argentina's undersea mineral resources.

An inventory of basic geological studies in Argentina, compiled by Methol (1963), contains very few references to coastal and undersea geology. Many of the coastal-geology studies mentioned in the inventory contain valuable information which can be extrapolated to the adjacent continental area lying below the surface of the sea. In his inventory, Methol cites 1,924 basic articles (published and unpublished), accompanied by numbered charts which can be used for rapid location of the bibliography covering a particular area.

Among these, mention should be made of the studies on calcareous conglomerates by Cortelezzi (1954) and on the age of the steps of Argentina's continental shelf by Groeber (1948).

3. UNDERSEA STUDIES

There have also been general studies relating to the continental shelf by Urien and Mouzo (1967) and by Urien (1967) mentioning the former lines of beaches now submerged which are important either for their high calcareous-mineral content or for their high percentage of heavy minerals (titanite, ilmenite and magnetite). Other authors, such as Granelli, have called attention to their probable economic potential and the need for evaluating it.

Investigations relating to former shorelines now lying close to the present edge of Argentina's undersea continental shelf are those of Fray and Ewing (1963) and of Richards and Craig (1963).

Among studies of detrital materials contained in Argentina's continental shelf, mention should be made of the studies conducted by Harrison Mathews (1934) of the Discovery Expedition, which make reference to the existence of glauconite (p. 201, loc. cit.).

McKelvey and Wang's "Preliminary Map of World Subsea Mineral Resources", presented to the United Nations (1970), shows on sheet 4 some areas of the Argentine continental shelf and its boundary, with the probable existence of phosphorus nodules, known as phosphorites.

Among the known deep-sea resources close to Argentina, we may mention the extensive regions of the sea bottom in Drake Passage, covered with nodules of manganese in various concentrations, described by Goodell (1968), the mineralogy and geochemistry of which have been studied by Meylan (1968).

4. GEOPHYSICAL AND GEOLOGICAL INVESTIGATIONS

Beginning in the International Geophysical Year, the Naval Hydrography Service, acting alone or in co-operation with Argentine and foreign universities, has carried out geophysical and geological investigations of the adjacent seas, including both the continental shelf and the deep sea (Capurro, Vila and Delneri, 1965).

An extensive bibliography on these investigations is given in "The Crust of the Earth in the South-West Atlantic" and in "Marine Geology and Geophysics" by Vila (1968 and 1970). The most important studies include those made by the Lamont Geological Observatory, now called the Lamont-Doherty Geological Observatory. These studies and investigations may be grouped under two headings: continental-shelf studies and deep-sea studies.

4.1. Continental shelf

The first important publication on the subject "Geophysical Investigations of the Submerged Coastal Plain of Argentina" by Ewing, Ludwig and Ewing (1964), was followed by others, such as "The Structure of the Argentine Continental Margin" by Ludwig, Ewing and Ewing (1968), "Structure of the Continental Terrace of Southern Brazil and Argentina" by Urien and Zambrano, "Geological Features in Southern Argentina and Their Extension into the Sea" by Zambrano and Urien (1970) and "Sedimentary Basins in the Argentine Continental Shelf" by Zambrano (1971). The last two studies were supplemented with geological information from the National Hydrocarbons Administration. In the last publication mentioned, Zambrano describes the petroleum potential of the various sedimentary basins.

4.2. Argentine basin

The deep-sea geophysical and geological studies relate basically to the continental margin and the sedimentary structure of the bottom. From research done by the Lamont Geological Observatory in co-operation with the Naval Hydrography Service, it has been determined that the Argentine basin contains the largest volume of ocean-bottom sediments, formed mainly by sediments of terrestrial origin carried thither by turbulent currents in the undersea canyons across the continental margin (Ewing and Ewing, 1965, and Ewing, Ludwig and Ewing, 1964).

4.3. Gravity and magnetism

Other geophysical investigations have been conducted by the Naval Hydrography Service in co-operation with the School of Engineering of the University of Buenos Aires and with the Petroleum Deposits Administration (Yacimientos Petrolíferos Fiscales). The magnetic surveys conducted for the Petroleum Deposits Administration and those conducted by the Naval Hydrography Service during the Years of the Quiet Sun (Orellana and Delneri, 1964; Vila, 1964, 1968 and 1969) have made it possible to determine the general lines of the magnetic field of the Argentine sea and to establish the absence of the continental-margin anomalies which are so characteristic of the east coast of North America. The studies involving the School of Engineering were executed by the Institute of Geodesy and Geophysics and are essentially gravimetric studies conducted off the coast of Buenos Aires Province.

5. PETROLEUM RESOURCES

Research on undersea petroleum resources began with the above-mentioned geological and geophysical investigations. Subsequent research for the purpose of prospecting for hydrocarbons has been carried out by the Government under the Hydrocarbons Act, No. 17319.

The Office of the President of the Republic, in a pamphlet of the General Secretariat, has produced a report on the status of the exploitation of "Petroleum and Gas" (1969) pages 13 and 14 of which refer to undersea studies.

Geophysical and geological exploration for petroleum and the probable subsequent exploitation of petroleum are carried out under contracts concluded with petroleum companies pursuant to the above-mentioned Act. Exploration is going on in three areas: in the Río Salado basin, between the Bay of San Borombón and Mar del Plata; in the Río Colorado or Bahía Blanca basin, between Claromecó in Buenos Aires Province and the mouth of the Río Negro; and in the Golfo de San Jorge basin. Details of the bidding for these contracts may be found in Petrotecnia, the informational publication of the Argentine Petroleum Institute (1967 and 1969).

The present status of the investigation of petroleum resources in the Argentine continental shelf within the limits of national jurisdiction is known to each company that has engaged in exploration, to the extent that it is involved, and is also known to the Government through the National Hydrocarbons Administration (Zambrano, 1971) and to the Petroleum Deposits Administration. The only information that has been made public with regard to the results of undersea drillings carried out under contract is the information presented by Zambrano (*loc. cit.*) in 1971 in his lecture to the Argentine Petroleum Institute.

6. BIBLIOGRAPHY[1/]

1/ The list is not included in this report but is available for reference.

BAHRAIN

/Original: English/
22 February 1973

The only information available in this respect is that there is a possibility of the discovery of off-shore oil within the limits of the State jurisdiction of Bahrain.

BELGIUM

/Original: French/
1 February 1973

The marine zone beyond the limits of national jurisdiction which has been provisionally assigned by the Geneva Convention to Belgium covers approximately 253,400 hectares.

No systematic research has yet been conducted on this zone. By extrapolation of information acquired on land, geologists see this zone as the extension of the Brabant Massif, covered by its relatively thin mantle of Cretaceous and Tertiary deposits.

This mobile cover deprives Belgium of any hope of finding mineral ores on the sea bottom. The chances of finding hydrocarbons are minimal, in view of the very great age of the Brabant Massif in this region and the absence of Permian or Triassic formations.

CANADA

/Original: English/
6 March 1973

Mineral resource potential of Canadian continental shelf

Oil and gas

The search for oil and gas on the Canadian continental shelf has been carried out continuously since 1960, and since that date the petroleum industry has spent in the order of $270 million for exploration. By the end of 1972, 72 wells had been drilled in Canada's continental shelf, including 57 off the East Coast, 14 off the West Coast, and one in Hudson Bay. In addition, 200,000 miles of marine geophysical surveys have been carried out, three-quarters of which were on the East Coast continental shelf.

Although encouraging shows of gas and oil have been encountered in several wells drilled on the East Coast shelf, in particular in the Sable Island area, no single commercially viable hydrocarbon accumulation has been found to date in the Canadian continental shelf. However, the off-shore portion of a number of promising sedimentary basins in the high Arctic have not as yet been tested by the drill.

In all areas of the continental shelf of Canada exploration is at too early a stage to make a meaningful assessment of the ultimate oil and gas potential.

Minerals other than oil and gas

The potential for non-hydrocarbon minerals on Canada's continental shelf is virtually unknown. Although Canada has probably the longest coastline of any nation in the world, no mineral deposits of economic value have been found to date.

The attached table provides estimated areas of continental shelf appertaining to Canada for some of the various proposals on limits of national jurisdiction presented so far to the Committee on the Peaceful Uses of the Sea-Bed and the Ocean Floor beyond the Limits of National Jurisdiction. Areas of the continental shelf which are thought to have potential for oil and gas by reason of their underlying sedimentary basins are also shown, as are very approximate volumes of sedimentary rocks in each area. The latter have been derived by indirect methods such as seismic and magnetic surveys and can therefore be considered only as relative orders of magnitude.

Region of Canadian continental shelf	Proposals for defining outer limit of sea-bed jurisdiction			
	200 metres	Edge of physical shelf	Limit of continental margin (base of slope)	200 nautical mile zone
<u>East coast off-shore</u> (to Hudson Strait)				
Total area*	230,000	350,000	560,000	565,000
Area underlain by sedimentary basins*	160,000	280,000	490,000	495,000
Volume of sediments**	400,000	660,000	1,660,000	1,500,000
<u>West coast off-shore</u>				
Total area*	30,000	35,000	50,000	175,000
Area underlain by sedimentary basins*	26,000	31,000	42,000	70,000
Volume of sediments**	50,000	60,000	70,000	100,000
<u>Arctic off-shore</u>				
Total area*	420,000	660,000	900,000	980,000
Area underlain by sedimentary basins*	380,000	620,000	860,000	940,000
Volume of sediments**	800,000	1,500,000	2,000,000	2,100,000
<u>Totals</u>				
Total area*	680,000	1,045,000	1,510,000	1,720,000
Area underlain by sedimentary basins*	566,000	931,000	1,392,000	1,505,000
Volume of sediments**	1,250,000	2,220,000	3,730,000	3,700,000

* All areas in square statute miles.

** Volumes in cubic miles.

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GUATEMALA

/Original: Spanish/
13 April 1973

The potential of Guatemala's sea-bed resources has not been investigated with a view to determining their mineralogical potential; the only studies carried out have been aimed at investigating the existence of hydrocarbons.

The scanty information available concerning the sea bottom near the coast seems to indicate the presence of black sands rich in magnetite (with some titanium) and other iron oxides in the Pacific Ocean and of siliceous and calcareous sands of coral origin in the Atlantic.

IRELAND

/Original: English/
26 February 1973

The Permanent Representative of Ireland has the honour to inform the Secretary-General that the Irish position is that exploration of Ireland's off-shore areas is still at an initial stage. A series of sedimentary basins have been noted around the Irish coasts and detailed investigation of these could lead to the discovery of oil and gas. Also, close to the western shores there is a possibility of the seaward extension to on-shore metal lode province. In the Irish Sea there exists the possibility of substantial quantities of sands and gravels suitable for building purposes which may be developed at a later stage.

IVORY COAST

/Original: French/
21 March 1973

The present state of our knowledge concerning the sea-bed adjacent to the Ivory Coast is not sufficient to provide any information concerning the potential of sea-bed mineral resources in this area.

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KHMER REPUBLIC

/Original: French/
23 February 1973

No thorough investigation of the Khmer Republic's sea-bed mineral resources has yet been conducted, with the exception of research on the detrital heavy minerals of our country's coastal deposits and the hydrocarbons on which research is now being done in the Khmer continental shelf.

1. Detrital heavy minerals

Prospecting is being carried on in the selected beach area from the Bay of Ream in the direction of Koh Kong and is still proceeding over large areas, wherever it is possible to move about in a zone of unquestioned security.

2. Hydrocarbons

In petroleum research, the year 1972 was marked by the drilling of the first off-shore stratigraphic bore-hole in our continental shelf.

This first drilling is a follow-up to the seismic campaigns of 1970 and 1971 and the interpretation studies resulting from them in both the geophysical and the geological fields. According to present plans, other seismic campaigns will be conducted in 1973 before any further bore-holes are drilled.

LIBERIA

/Original: English/
14 February 1973

Research so far conducted in Liberia's territorial waters has been programmed for stratigraphy and structural patterns with little or no emphasis on potential mineral deposition. However, exploratory work for petroleum encountered encouraging geological phenomena for probable hydrocarbon accumulation.

For the immediate future, the Government of Liberia's objectives include evaluation of the mouths of the major rivers for potential placer deposits.

NETHERLANDS

/Original: English/
26 April 1973

Following is a contribution by the Royal Dutch Shell Group on request of the Netherlands Government, for possible use in the United Nations study on the economic significance of various limit proposals in the Sea-Bed Committee.

Appendix I contains a list of estimated ultimate recoverable reserves of oil and natural gas liquids in off-shore fields under water depths of less than 200 metres - reserves of the continental shelf in the strict sense. In the list a distinction is made between fields situated between 0 and 40 nautical miles from the coast and fields situated between 40 and 200 nautical miles.

Appendix II is a map indicating:1/

1. Off-shore sedimentary basins locally favourable for oil and gas (green colour);

2. Off-shore concessions and parts thereof located beyond 200 m water depth awarded as at 1-1-1973 (blue colour);

3. The 200 m depth line;

4 The 200 nautical miles line from nearest land.

Appendix III concerns measurements of the following marine areas in square kilometres (km^2):

1. The area between the coast and the 3,000 metre depth line;

2. The area between the coast and the 200 nautical mile line;

3. The area covered by sediments of more than 1,000 metre thickness (considered to be generally the minimum thickness needed for the existence of recoverable oil and gas reserves).

In order to avoid misunderstandings it is pointed out that the area mentioned under 3, in appendix III, is not identical to the area considered locally favourable for the existence of oil and gas as referred to under 1 in appendix II, although in their global totality the surfaces of both areas do not differ substantially.

It is also interesting to note that the 3,000 m depth line (area 1, appendix III) delimits in many places areas substantially smaller than the area covered by more than 1,000 m thick sediments (area 3, appendix III). The total of the first area, however, is not very much smaller than the total of the latter area: 69 million km^2 and 88 million km^2 respectively.

1/ This map will be distributed separately.

The sedimentary area considered locally favourable for oil and gas - shown on the map - has been determined on the basis of knowledge as it exists today. It must not be assumed, therefore, that all areas outside the "green belt" cannot offer oil and gas prospects. Actual knowledge of deep sea sediments is still limited and it is therefore possible that one may conclude in the future that the prospective area is (much) larger.

Appendix IV addresses itself to the question of possible future technological developments in the exploitation of possible oil and gas deposits up to water depths of 3,000-5,500 metres (average seaward edge of the continental rises). The expectation is ventured that, although there is as yet no active research on problems to be solved for exploitation of hydrocarbons at depths beyond 3,000 m, technical capabilities for such exploitation could be developed one day if economically justified.

APPENDIX I

OIL AND NATURAL GAS LIQUIDS

ESTIMATED ULTIMATE RECOVERABLE RESERVES
(in millions of barrels, May 1972)

IN OFF-SHORE FIELDS

COUNTRY	0-40 Naut. Miles <200 m in water depth	40-200 Naut. Miles <200 m in water depth
North America		
Alaska (Cook Inlet)	750	
California	5,400	
Louisiana	12,000	
South America		
Trinidad	725	
Peru	30	
Brazil	370	
Europe		
Norway		1,800
United Kingdom		3,000
Denmark		385
Netherlands		5
Spain	65	
Middle East		
Iran	2,000	7,700
Neutral Zone		10,000
Saudi Arabia	40,000	
Abu Dhabi	1,000	15,000
Dubai		3,000

(Appendix I continued on following page)

APPENDIX I (continued)

COUNTRY	0-40 Naut. Miles <200 m in water depth	40-200 Naut. Miles <200 m in water depth
Africa		
Egypt	1,800	
Tunisia	130	
Nigeria	3,400	
Gabon	280	
Congo Brazzaville	730	
Angola	1,085	
Far East		
Japan	25	
Malaysia	200	
Brunei	800	
Indonesia	1,240	
Australasia		
Australia	710	1,060
New Zealand	170	

Note: Information compiled of various published data.

APPENDIX III

Area computations

The following off-shore areas have been measured:

1. Area from the coastline to the 3,000 m isobath

2. Area from the coastline to a distance of 200 nautical miles off shore

3. Area with sediment thickness in excess of 1,000 metres.

A. Source of data

The general bathymetric charts of the ocean by the International Hydrographic Office of Monaco were used as a basis for the calculations. The scale of these maps is 1:10 million at the equator.

The 3,000 m isobath was taken as shown on the maps. The 200 nautical mile equidistance line was traced from the coastline of continents and islands.

To determine the area of sediment thickness in excess of 1,000 m, published geological maps of several major oceanographic institutes were used. Because of the wide spacing of seismic control these figures are affected with an error in excess of 10 per cent.

Arctic and Antarctic regions are not included in the tabulations.

The results of the calculations are shown in tabulated form on figure I.

Figure II shows the geographical subdivision used for the computation.

B. General results

On a world-wide basis the area inside the 200 nautical miles equidistance line includes 116 million km^2. This area is about 24 per cent larger than the area with sediments in excess of 1,000 m, which measures 88 million km^2. The smallest of all three areas is the region above the 3,000 m isobath with a total of 69 million km^2.

Fig. I. Table belonging to appendix III	Area between coast and the 3,000 m isobath line (in km^2)	Area between coast and 200 N. mile line (in km^2)	Area covered by sediments of more than 1,000 m thickness (in km^2)
I. North America Pacific Margin	1,015,873	1,536,837	947,315
II. North America-Greenland Atlantic Margin	4,161,441	4,725,411	6,716,181
III. Central America + Mexico Pacific Margin	1,657,269	3,286,904	1,168,989
IV. Carib. Area-Gulf of Mexico-Bahamas	1,453,254	3,418,563	3,466,964
V. South America Pacific Margin	2,408,042	4,395,140	1,513,166
VI. South America Atlantic Margin	4,388,362	6,325,656	12,695,316
VII. Europe Atlantic Margin	4,858,950	4,409,607	4,271,980
VIII. Europe Mediterranean	1,632,024	1,815,815	1,815,815
IX. Africa Mediterranean	662,763	717,599	717,599
X. West Africa Atlantic Margin	2,117,486	5,305,563	6,328,275
XI. South and East Africa	5,053,057	9,264,697	6,500,606
XII. Middle East	1,043,218	1,360,542	1,489,531
XIII. Far East	10,231,347	19,932,617	12,087,706
XIV. Australia-New Zealand-Tonga	15,470,846	21,492,784	21,479,715
XV. Asia Pacific Margin	5,548,270	10,035,637	6,188,856
XVI. Asia Interior Seas	579,909	579,909	579,909
XVII. Pacific	4,337,409	15,412,687	---
XVIII. Mid-Atlantic Ridge	2,189,947	2,172,218	---
TOTAL	68,809,467	116,188,186	87,967,923

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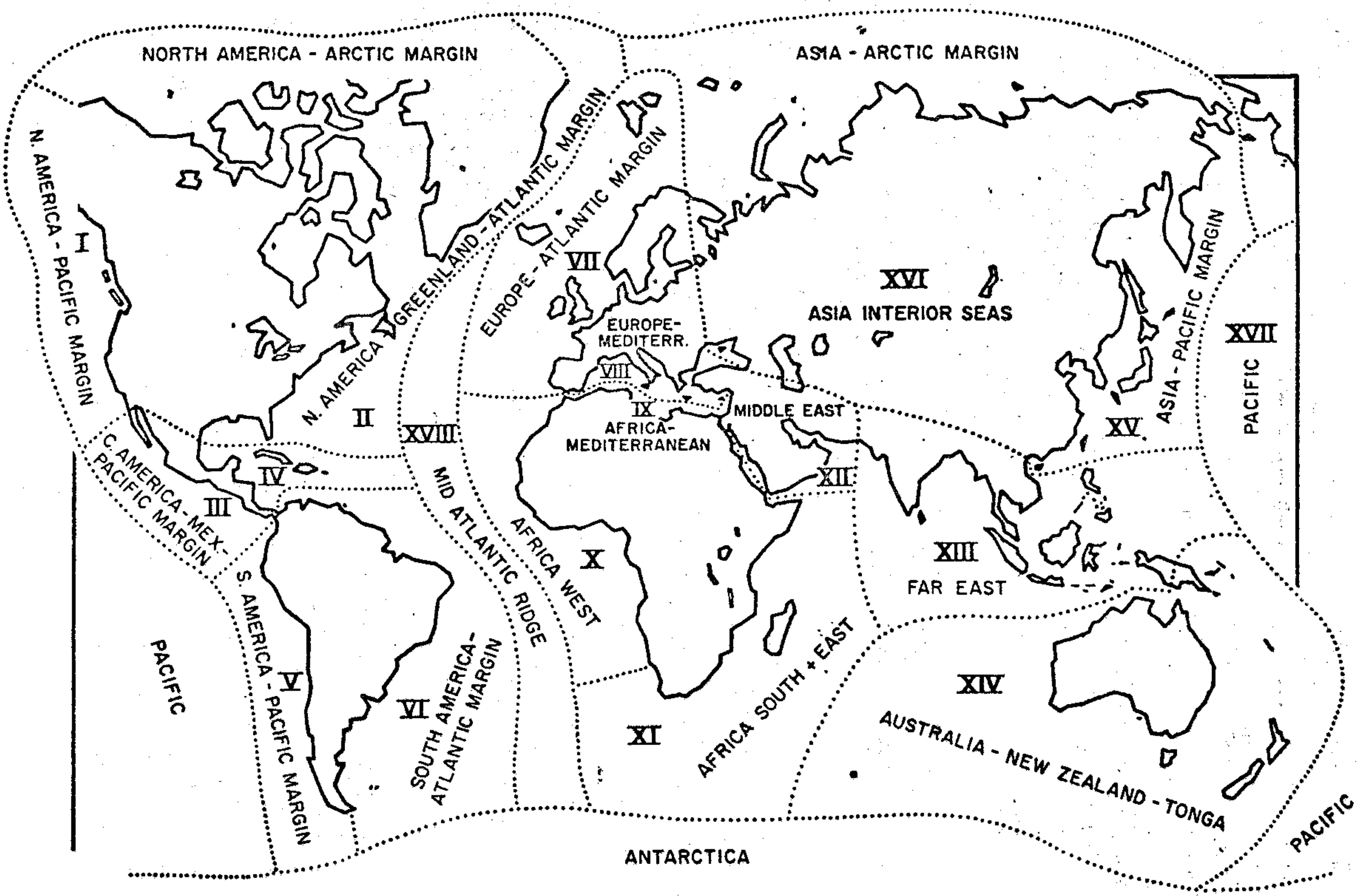

GEOGRAPHICAL DESIGNATIONS OF OFFSHORE AREAS
(These are not the territorial boundaries of the Geneva Convention)

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APPENDIX IV

The possibilities of developing deep-sea oil and gas reserves

In recent years the oil industry, with its deep-sea exploration activities, has clearly moved towards the development of possible oil and gas reserves which have hitherto remained inaccessible. These days it is possible, without the direct danger of blow-outs, to drill at water depths of approximately 500 m using a blow-out preventer on the sea-bed operated by means of electro-hydraulic signals.

The technical knowledge and experience being gained are of such a nature that we may safely state that within a few years drilling without risk will be possible in water of more than 1,000 m depth.

The appropriate equipment for the development of oil or gas accumulations struck in water depths down to 1,000 m has now reached such a stage that the production of such reserves, provided they are sufficiently large, will be an economic proposition.

Technically, greater depths impose further restrictions on the possibilities of drilling for oil and gas, but here again, the ultimate decisive factor will not be of a technical nature but one of economics. For the time being work is being concentrated on those problems which have been recognized as affecting water depths between 1,000 and 3,000 m, but there is every reason to assume that once these problems have been overcome it will be possible to commence work at even greater depths, for example in the area between the abyssal plain and the continental slope.

Very probably, the methods used to work at such great depths will differ considerably from those at present in use on the continental shelf. In particular, it is to be expected that a good deal of the work, both drilling and production, will take place on the sea-bed itself instead of at the surface, as is the case at present. We will then be faced with an environment (see water at high pressure) as hazardous and alien as that faced in space exploration.

It is therefore also to be expected that, just as in space exploration, robot tools will be used in addition to or in combination with manned equipment. The great advantage of this sort of tool is that protection against high water pressures will be less expensive than in manned equipment and plant.

Studies will undoubtedly be made, especially from the viewpoint of production, into the possible benefits which may be derived from local variations in height of the sea-bed. The proximity of a submarine ridge would certainly open up possibilities for the location of storage installations, which would then be more readily accessible to, for example, tankers at the surface. Research will also be certainly carried out into the possibility of allowing storage vessels filled with oil to float at a certain depth, which will require the solution of problems of anchoring the vessels to the sea-bed or to an installation floating on the surface.

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Of course, the oil industry will always weigh the desirability of this type of enterprise against the ultimate volume of the deposit and the resultant production of energy, which will have to compensate for the expenditure required for development.

SAUDI ARABIA

/Original: English/
16 March 1973

The Permanent Mission of Saudi Arabia to the United Nations has the honour to enclose herewith the following documentation: 1/

1. Royal Decree, in Arabic, No. 27/M dated 9/7/1388 A.H. approving the acquisition of the Red Sea resources.

2. Arabic text of the law relating to the acquisition of the Red Sea resources.

3. English translation of the law relating to the acquisition of the Red Sea resources.

4. A note on the Saudi Arabian law relating to the ownership of the Red Sea resources prepared by Mr. Mohamed T. Al-Ghonaimi.

5. Explanatory notes on the draft resolution for the acquisition of the Red Sea resources.

1/ The texts of these documents are not reproduced here; they are available for consultation.

SWEDEN

/Original: English/
30 January 1973

In recent years, the natural resources of the sea have attracted greatly increased interest throughout the world. Many of the traditional raw materials of the land areas have become scarce as a result of exploitation, while demand has been rapidly rising. Also, modern techniques have made it increasingly possible to work at sea for the purpose of exploiting its resources.

A number of countries already have major oceanic research programmes, and exploit the sea on a large scale. Large oceanic research programmes are being carried out under international auspices.

These factors have provided the background to the work of the Commission on Oceanic Resources. Of basic importance to the Commission were also the existing rights of exploitation in accordance with the 1958 Geneva Convention on continental shelves. The Swedish continental shelf comprises some 40 per cent of the country's dry surface. The basic question posed to the Commission has been how far - and in what way - Sweden can and should take part in exploiting the resources of the sea....

Swedish marine exploitation of minerals comprises at present only minor quantities of sand and gravel.

It is impossible at present to form any well-grounded opinion as to the scale of Swedish mineral exploitation of the sea in future years. It will depend, among other things, on the finds made within the Swedish continental shelf area. This is something we know very little about, since the shelf has been very imperfectly mapped geologically.

The basic condition necessary for the mineral exploitation of Swedish waters on a larger scale is that the shelf should be mapped geologically. The Commission therefore proposes a complete mapping of the shelf.

Maps will cover loose deposits, crystalline basement rocks and to some extent also sedimentary rock areas.

Loose deposits will be mapped mainly by seismic methods. The mapping of the entire Swedish continental shelf area is estimated to take about 15 years, and cost in all some SKr 30 million. The project is of great interest, as it will provide information on the existence of, for instance, sand and gravel deposits. As the openings for sand and gravel exploitation on land areas decline and demand increases, the resources on the Swedish continental shelf - which as far as can be judged are very large - will attract increasing interest. In the long term, one can foresee the extraction of sand and gravel from Swedish sea-beds on a financially considerable scale. Even if the complete mapping project is expected to take 15 years, the most prospective sand and gravel areas should have been covered within 6 to 7 years. Loose deposits are to be mapped also with a view, for instance, to possible deposits of heavy mineral sands and nodules.

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Even if the mapping of loose deposits is motivated mainly by the possibility of future mineral extraction, the Commission considers it of great value also from other aspects. Above all, an increased knowledge of the loose deposits will improve our knowledge also of environmental conditions in the sea.

The proposed mapping of crystalline rock areas will involve e.g. aerial magnetic surveys gravity measurements and rock sampling. These surveys are expected to extend over a period of about 15 years. Mapping will cost a total of SKr 8.3 million. Areas with good prospectivity for ore deposits should be covered first. These include the shelf area in the Gulf of Bothnia outside the Skellefte field.

The sedimentary rock areas on the Swedish shelf are interesting from the mineral standpoint, mainly because they may contain oil and gas finds. Hydrocarbon prospecting is already taking place in these areas, under the auspices of Oil Prospecting AB (OPAB). The Commission therefore proposes no further field work in respect of the sedimentary rock areas.

However, the primary geological data on the sedimentary rock areas obtained from OPAB's operations and in other ways can be utilized as a basis for a geological map of these areas. The Commission proposes that such a map be produced, largely because of its considerable scientific interest. Since all the field-work will be performed in other contexts, the estimated cost of the map is only SKr 1.2 million.

As already mentioned, the extraction of sand and gravel from the continental shelf around Sweden will be of future importance. Such exploitation is of great commercial interest, and offers the marked advantages of large-scale operations. For these and other reasons, the Commission finds that the establishment of a firm for the extraction of sand and gravel from sea areas should be considered. The State has a major interest in such activities, among other things as the granter of concessions and as the environmental authority in the sea area. Experience of the exploitation and marketing of sand and gravel is available in private firms. The proposed firm could thus be made a semi-State body. It should also be emphasized that extremely interesting development work in the field of marine techniques should be possible in connexion with the extraction of sand and gravel.

The Commission states in various contexts, both in the chapter on minerals and elsewhere, that Swedish efforts to exploit the sea could take various forms. Apart from exploitation, we can also develop and manufacture the relevant equipment. Such development and manufacture could aim, for instance, at exports. This aspect is of great interest, particularly in the field of mineral extraction.

For such development and manufacture for different markets to be successfully realized, a good technical and economic overview of the market is needed. The Commission considers that the proposed Delegation for Oceanic Resources should be requested to compile such market information. In this way, the delegation could provide a service of interest above all to small and medium-sized Swedish firms engaged in technical marine projects.

As regards the extraction of minerals, the Commission states - as with exploitation for food-stuffs - that the possibilities of Swedish aid to the developing countries should be considered.

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TURKEY

/Original: English/
5 January 1973

1. In the Black Sea, which is a semi-enclosed sea, the Turkish Government has undertaken several exploration activities for oil and natural gas within the established criterion of continental shelf through its own means as well as through granting licences. These activities did not produce any positive results which would indicate the existence of any mineral resources in the area explored so far.

2. The Aegean Sea is encircled by Turkish and Greek coastlines and mineral, oil and natural resources of this sea remain within the limits of national jurisdiction of these two countries.

3. In the Mediterranean, the Turkish Government is conducting exploration activities for oil and natural gas and is also granting licences for the same purpose. These activities which are still going on, have not yet produced any final results to determine the mineral, oil and natural gas resource potential of the region.

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (UNCTAD)

/Original: English/
15 March 1973

You may recall that, in the light of General Assembly resolution 2750 A (XXV) and UNCTAD resolution 51 (III) (to which I referred in my letter to you of 21 July 1972), the UNCTAD secretariat has addressed itself to the question of the consequences for world markets and for the economies of developing countries resulting from the exploitation of the resources of the sea-bed. In co-operation between the Commodities Division of UNCTAD and the Ocean Economics and Technology Branch of your Department, we contributed to two reports submitted by the Secretary-General to the Committee on the Peaceful Uses of the Sea-Bed on the subject of the possible economic implications of mineral production from the international sea-bed area (documents A/AC.138/36 and 73).

For the purposes of our own analyses, by arrangement between our respective units, the UNCTAD secretariat has relied upon information assembled by the Ocean Economics and Technology Branch on the extent and likely utilization of the mineral resources of the international sea-bed area. Accordingly, we do not ourselves possess any original information on the question of the extent and the economic significance, in terms of resources, of the international area that would result from the various proposed limits of national jurisdiction.

However, certain reports which we have previously made available to your Department may be helpful in the proposed work. These are a study by the UNCTAD secretariat of problems of the world market for manganese ore (document TD/B/C.1/105), and a preliminary version of a report, prepared by a consultant, on the possible impact of sea-bed production on the cobalt market. I shall ensure that any additional relevant information which is obtained in the course of our further work is forwarded to the Department of Economic and Social Affairs.

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UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION (UNESCO)

/Original: English/
5 March 1973

We look upon your own excellent publications as the basic source of information of the type you seek and very much regret that we have little additional material to offer.

However, your request has been transmitted to the Engineering Committee on Oceanic Resources (ECOR), one of the Scientific Advisory Bodies of the Intergovernmental Oceanographic Commission (IOC), in the hope that they will be able to assist.

ANNEX II

SUPPORTING TABLES ON HYDROCARBONS AND NODULES

TABLE A.3.1

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

WESTERN NORTH ATLANTIC

Zone	Area	Production			Proved	Discovered
	10^6 sq. km	1972	1980 (est.)	Cumulative	Reserves	to 1-1-1973
Landward of 200 m. isobath	5.22	1,324	1,500	9,650	15,745	25,395
Seaward of 200 m. isobath	27.41	---	---	---	---	---
Landward of 3,000 m. isobath	9.20	1,324		9,650	15,745	25,395
Seaward of 3,000 m. isobath	23.43	---	---	---	---	---
Landward of 40 miles from coast	4.14	1,324**		9,650**	15,745**	25,395**
Seaward of 40 miles from coast	28.75	---	---	---	---	---
Landward of 200 miles from coast	15.80	1,324		9,650	15,745	25,395
Seaward of 200 miles from coast	16.83	---	---	---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

** An indeterminate very small fraction of these amounts occurs just seaward of 40 miles from the coast.

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TABLE A.3.2

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

EASTERN NORTH ATLANTIC

Zone	Area 10^6 sq. km	Production 1972	Production 1980 (est.)	Production Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	3.37	300	950	1,000	24,200	25,200
Seaward of 200 m. isobath	22.11	---		---	---	---
Landward of 3,000 m. isobath	9.85	300		1,000	24,200	25,200
Seaward of 3,000 m. isobath	17.18	---		---	---	---
Landward of 40 miles from coast	3.77	270		800	7,000	7,800
Seaward of 40 miles from coast	21.72	30		200	17,200	17,400
Landward of 200 miles from coast	12.03	300		1,000	24,200	25,200
Seaward of 200 miles from coast	13.45	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.3

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

WESTERN SOUTH ATLANTIC

Zone	Area 10^6 sq. km	Production 1972	1980 (est.)	Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	1.50	---	35	---	25	25
Seaward of 200 m. isobath	25.95	---		---	---	---
Landward of 3,000 m. isobath	3.06	---		---	25	25
Seaward of 3,000 m. isobath	24.13	---		---	---	---
Landward of 40 miles from coast	.77	---		---	25	25
Seaward of 40 miles from coast	26.68	---		---	---	---
Landward of 200 miles from coast	4.67	---		---	25	25
Seaward of 200 miles from coast	25.11	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.4

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

EASTERN SOUTH ATLANTIC

Zone	Area 10^6 sq. km	Production 1972	1980 (est.)	Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	.21	64.3	140	197	5,068	5,265
Seaward of 200 m. isobath	21.04	---		---	---	---
Landward of 3,000 m. isobath	1.08	64.3		197	5,068	5,265
Seaward of 3,000 m. isobath	20.18	---		---	---	---
Landward of 40 miles from coast	.26	64.3		197	5,068	5,265
Seaward of 40 miles from coast	21.00	---		---	---	---
Landward of 200 miles from coast	1.11	64.3		197	5,068	5,265
Seaward of 200 miles from coast	20.15	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.5

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

WESTERN NORTH PACIFIC

Zone	Area 10^6 sq. km	Production 1972	Production 1980 (est.)	Production Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	5.05	36.33	140	101	3,235	3,336
Seaward of 200 m. isobath	38.71	---		---	---	---
Landward of 3,000 m. isobath	8.21	36.33		101	3,235	3,336
Seaward of 3,000 m. isobath	35.56	---		---	---	---
Landward of 40 miles from coast	.92	36.33		101	3,235	3,336
Seaward of 40 miles from coast	42.84	---		---	---	---
Landward of 200 miles from coast	14.32	36.33		101	3,235	3,336
Seaward of 200 miles from coast	29.71	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.6

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

EASTERN NORTH PACIFIC

Zone	Area 10^6 sq. km	Production 1972	Production 1980 (est.)	Production Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	.86	150	200	400	600	1,000
Seaward of 200 m. isobath	42.91	---		---	---**	---
Landward of 3,000 m. isobath	1.41	150		400	600	1,000
Seaward of 3,000 m. isobath	42.36	---		---	---	---
Landward of 40 miles from coast	.60	150		400	600	1,000
Seaward of 40 miles from coast	43.17	---		---	---	---
Landward of 200 miles from coast	2.88	150		400	600	1,000
Seaward of 200 miles from coast	40.89	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

** Does not include major reserves indicated in Santa Barbara Channel in water depths of 189-396 metres.

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TABLE A.3.7

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

WESTERN SOUTH PACIFIC

Zone	Area 10^6 sq. km	Production 1972	Production 1980 (est.)	Production Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	1.68	117	180	247	6,000	6,247
Seaward of 200 m. isobath	45.22	---		---	---	---
Landward of 3,000 m. isobath	4.46	117		247	6,000	6,247
Seaward of 3,000 m. isobath	42.44	---		---	---	---
Landward of 40 miles from coast	1.92	117**		247**	6,000**	6,247**
Seaward of 40 miles from coast	44.98	---		---	---	---
Landward of 200 miles from coast	9.56	117		247	6,000	6,247
Seaward of 200 miles from coast	37.34	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

** An indeterminate small fraction of these amounts occur just seaward of 40 miles from the coast.

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TABLE A.3.8

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

EASTERN SOUTH PACIFIC

Zone	Area 10^6 sq. km	Production 1972	Production 1980 (est.)	Production Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	.14	12.17	15	70	183	253
Seaward of 200 m. isobath	46.76	---		---	---	---
Landward of 3,000 m. isobath	.88	12.17		70	183	253
Seaward of 3,000 m. isobath	46.02	---		---	---	---
Landward of 40 miles from coast	.68	12.17		70	183	253
Seaward of 40 miles from coast	46.22	---		---	---	---
Landward of 200 miles from coast	3.62	12.17		70	183	253
Seaward of 200 miles from coast	43.28	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.9

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

WESTERN INDIAN OCEAN

Zone	Area 10^6 sq. km	Production 1972	Production 1980 (est.)	Production Cumulative	Proved Reserves	Discovered to 1-1-1973
Landward of 200 m. isobath	1.81	1,285	2,500	9,300	88,600	97,733
Seaward of 200 m. isobath	34.45	---		---	---	---
Landward of 3,000 m. isobath	3.33	1,285		9,300	88,600	97,733
Seaward of 3,000 m. isobath	32.93	---		---	---	---
Landward of 40 miles from coast	1.37	1,285		9,300	88,600	97,733
Seaward of 40 miles from coast	34.89	---		---	---	---
Landward of 200 miles from coast	7.27	1,285		9,300	88,600	97,733
Seaward of 200 miles from coast	29.25	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.10

PETROLEUM PRODUCTION, RESERVES AND CUMULATIVE DISCOVERIES*

EASTERN INDIAN OCEAN

Zone	Area 10^6 sq. km	Production			Proved Reserves	Discovered to 1-1-1973
		1972	1980 (est.)	Cumulative		
Landward of 200 m. isobath	2.06	---	75	40	2,580	2,620
Seaward of 200 m. isobath	35.80	---		---	---	---
Landward of 3,000 m. isobath	3.94	---		40	2,580	2,620
Seaward of 3,000 m. isobath	33.92	---		---	---	---
Landward of 40 miles from coast	1.23	---		---	---	---
Seaward of 40 miles from coast	36.62	---		40	2,560	2,620
Landward of 200 miles from coast	5.82	---		40	2,560	2,620
Seaward of 200 miles from coast	32.03	---		---	---	---

* Expressed in 10^6 barrels of oil. Figures include oil plus oil equivalent of the gas (6,000 cu. ft. of gas equals one barrel of oil).

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TABLE A.3.11

PROPORTION OF SAMPLE WITHIN AND OUTSIDE OF THE 200 MILE ZONE

REGION	Ni		Cu		Co	
	No. of point	Per cent	No. of point	Per cent	No. of point	Per cent
(1) Indian Ocean	60	100	61	100	61	100
(a) Outside the 200 naut. mi. zone	51	85	52	85.2	52	85.2
(b) Within the 200 naut. mi. zone	9	15	9	14.8	9	14.8
(2) Atlantic Ocean	94	100	94	100	94	100
(a) Outside the 200 naut. mi. zone	76	80.8	76	80.8	76	80.8
(b) Within the 200 naut. mi. zone	18	19.2	18	19.2	18	19.2
(3) Pacific Ocean	478	100	465	100	468	100
(a) Outside the 200 naut. mi. zone	324	67.8	326	67.8	333	67.8
(b) Within the 200 naut. mi. zone	154	32.2	139	32.2	135	32.2
(4) Total Oceans	632	100	620	100	623	100
(a) Outside the 200 naut. mi. zone	451	71.4	454	73.2	461	73.9
(b) Within the 200 naut. mi. zone	181	28.6	166	26.8	162	26.1

TABLE A.3.12

ESTIMATES OF THE MEAN AND STANDARD DEVIATION
OF NODULE SAMPLES IN EACH OCEAN

REGION	Ni			Cu			Co		
	No. of points	Mean	Standard deviation	No. of points	Mean	Standard deviation	No. of points	Mean	Standard deviation
(1) North Indian	25	.57	.39	25	.17	.13	26	.26	.15
(2) South Indian	35	.44	.23	36	.20	.17	35	.30	.23
INDIAN OCEAN	60	.50	.31	61	.19	.15	61	.28	.20
(3) North Atlantic	37	.38	.27	37	.15	.11	37	.34	.16
(4) South Atlantic	57	.48	.34	57	.15	.12	57	.31	.31
ATLANTIC OCEAN	94	.44	.32	94	.15	.12	94	.32	.26
(5) North Pacific	253	.71	.44	236	.53	.43	251	.31	.25
(6) South Pacific	225	.67	.45	229	.38	.31	217	.37	.41
PACIFIC OCEAN	478	.69	.45	465	.46	.38	468	.34	.33
TOTAL OCEANS	632	.63	.43	620	.38	.36	623	.33	.31

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TABLE A.3.13

FREQUENCY DISTRIBUTION FOR ALL OCEANS

Interval	Ni				Cu				Co			
	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	21	21	.033	.033	131	131	.211	.211	91	91	.146	.146
.1-.2	61	92	.096	.129	147	278	.237	.448	.45	236	.233	.379
.2-.3	82	164	.130	.259	73	351	.118	.566	127	363	.204	.582
.3-.4	71	235	.112	.371	44	395	.071	.637	105	468	.169	.751
.4-.5	77	312	.122	.493	63	458	.102	.736	76	544	.122	.873
.5-.6	57	369	.090	.583	28	486	.045	.783	22	566	.035	.908
.6-.7	45	414	.071	.655	30	516	.048	.832	10	576	.016	.924
.7-.8	36	450	.057	.712	30	546	.048	.880	7	583	.011	.935
.8-.9	26	476	.041	.753	10	556	.016	.896	10	593	.016	.951
.9-1.0	29	505	.046	.799	21	577	.034	.930	6	599	.010	.961
1.0-1.1	35	540	.055	.854	11	588	.018	.948	3	602	.005	.966
1.1-1.2	16	556	.025	.879	3	591	.005	.953	3	605	.005	.971
1.2-1.3	27	583	.043	.922	9	600	.014	.967	1	606	.002	.973
1.3-1.4	10	593	.016	.938	8	608	.013	.980	3	609	.005	.977
1.4-1.5	13	606	.020	.958	4	612	.006	.987	4	613	.006	.983
1.5-1.6	7	613	.011	.969	5	617	.008	.995	6	619	.010	.993
1.6-1.7	7	620	.011	.981	3	620	.005	1.000	0	619	-	.993
1.7-1.8	2	622	.003	.984					1	620	.002	.995
>1.8	10	632	.016	1.000					3	623	.005	1.000

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TABLE A.3.14

FREQUENCY DISTRIBUTION FOR THE PACIFIC OCEAN

Interval	Ni				Cu				Co			
	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	12	12	.025	.025	70	70	.150	.150	70	70	.149	.149
.1-.2	40	52	.083	.108	82	152	.176	.326	105	175	.224	.373
.2-.3	46	98	.096	.205	56	208	.120	.447	92	267	.196	.570
.3-.4	47	145	.098	.303	38	246	.082	.529	85	352	.182	.752
.4-.5	63	208	.132	.435	60	306	.129	.658	54	406	.115	.867
.5-.6	41	249	.085	.520	27	333	.058	.716	17	423	.036	.903
.6-.7	39	288	.081	.602	30	363	.064	.780	8	431	.017	.920
.7-.8	28	306	.058	.661	28	391	.060	.840	7	438	.015	.935
.8-.9	22	338	.046	.707	10	401	.022	.862	6	444	.013	.948
.9-1.0	26	364	.054	.761	21	422	.045	.907	3	447	.006	.955
1.0-1.1	31	395	.065	.826	11	433	.024	.931	3	450	.006	.961
1.1-1.2	14	409	.029	.855	3	436	.006	.937	2	452	.004	.965
1.2-1.3	23	432	.048	.903	9	445	.019	.956	1	453	.002	.967
1.3-1.4	9	441	.019	.922	8	453	.017	.974	3	456	.006	.974
1.4-1.5	12	453	.025	.947	4	457	.009	.982	3	459	.006	.980
1.5-1.6	6	459	.013	.960	5	462	.010	.993	5	464	.011	.991
1.6-1.7	7	466	.014	.974	3	465	.006	1.000	0	464	-	.991
1.7-1.8	2	468	.005	.979					1	465	.002	.993
>1.8	10	478	.021	1.000					3	468	.006	1.000

TABLE A.3.15

FREQUENCY DISTRIBUTION FOR THE ATLANTIC OCEAN

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	7	7	.074	.074	41	41	.436	.436	11	11	.117	.117
.1-.2	12	19	.128	.202	39	80	.415	.851	24	35	.255	.372
.2-.3	23	42	.244	.446	9	89	.095	.946	21	56	.223	.595
.3-.4	14	56	.149	.595	1	90	.011	.957	15	71	.159	.755
.4-.5	7	63	.074	.670	2	92	.021	.978	13	84	.138	.893
.5-.6	11	74	.117	.787	1	93	.011	.989	3	87	.032	.925
.6-.7	4	78	.042	.820	0	93	-	.989	1	88	.011	.936
.7-.8	6	84	.064	.893	1	94	.011	1.000	0	88	-	.936
.8-.9	1	85	.011	.904					2	90	.021	.957
.9-1.0	1	86	.011	.914					1	91	.011	.968
1.0-1.1	3	89	.032	.946					0	91	-	.968
1.1-1.2	1	90	.011	.957					1	92	.011	.979
1.2-1.3	3	93	.032	.989					0	92	-	.979
1.3-1.4	0	93	-	.989					0	92	-	.979
1.4-1.5	0	93	-	.989					1	93	.011	.990
1.5-1.6	1	94	.011	1.000					1	94	.011	1.000
1.6-1.7												
1.7-1.8												
>1.8												

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TABLE A.3.16

FREQUENCY DISTRIBUTION FOR THE INDIAN OCEAN

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	2	2	.033	.033	20	20	.328	.328	10	10	.164	.164
.1-.2	9	11	.15	.183	26	46	.426	.754	16	26	.262	.426
.2-.3	13	24	.217	.4	8	54	.131	.885	14	40	.229	.655
.3-.4	10	34	.167	.567	5	59	.082	.967	5	45	.082	.737
.4-.5	7	41	.116	.683	1	60	.016	.983	9	54	.148	.885
.5-.6	5	46	.083	.766	0	60	-	.983	2	56	.033	.918
.6-.7	2	48	.033	.8	0	60	-	.983	1	57	.016	.934
.7-.8	2	50	.033	.833	1	61	.016	1.000	0	57	-	.934
.8-.9	3	53	.05	.883					2	59	.033	.967
.9-1.0	2	55	.033	.916					2	61	.033	1.000
1.0-1.1	1	56	.017	.933								
1.1-1.2	1	57	.017	.95								
1.2-1.3	1	58	.017	.967								
1.3-1.4	1	59	.017	.983								
1.4-1.5	1	60	.017	1.000								
1.5-1.6												
1.6-1.7												
1.7-1.8												
>1.8												

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TABLE A.3.17

FREQUENCY DISTRIBUTION FOR TOTAL OCEANS OUTSIDE THE 200 MILE ZONE

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	11	11	.024	.024	80	80	.176	.176	56	56	.121	.121
.1-.2	32	43	.071	.095	98	178	.216	.392	126	182	.273	.394
.2-.3	58	101	.128	.224	60	238	.132	.524	98	280	.212	.607
.3-.4	48	149	.106	.330	35	273	.077	.601	85	365	.184	.791
.4-.5	54	203	.119	.450	49	322	.108	.709	47	412	.102	.893
.5-.6	41	244	.091	.541	20	342	.044	.753	11	423	.024	.917
.6-.7	35	279	.077	.618	20	362	.044	.797	7	430	.015	.932
.7-.8	21	300	.046	.665	23	385	.051	.848	5	435	.011	.943
.8-.9	21	321	.046	.711	10	395	.022	.870	8	443	.017	.960
.9-1.0	23	344	.051	.762	17	412	.037	.907	3	446	.006	.967
1.0-1.1	29	373	.064	.827	10	422	.022	.929	3	449	.006	.974
1.1-1.2	14	387	.031	.858	3	425	.007	.936	2	451	.004	.978
1.2-1.3	20	407	.044	.902	9	434	.020	.956	0	451	-	.978
1.3-1.4	9	416	.020	.922	8	442	.017	.973	3	454	.006	.984
1.4-1.5	11	427	.024	.946	4	446	.009	.982	2	456	.004	.989
1.5-1.6	6	433	.013	.960	5	451	.011	.993	5	461	.001	1.000
1.6-1.7	7	440	.015	.975	3	454	.007	1.000				
1.7-1.8	2	442	.004	.980								
>1.8	9	451	.020	1.000								

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TABLE A.3.18

FREQUENCY DISTRIBUTION FOR TOTAL OCEANS WITHIN THE 200 MILE ZONE

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	10	10	.055	.055	51	51	.307	.307	35	35	.216	.216
.1-.2	29	39	.16	.215	49	100	.295	.602	19	54	.117	.333
.2-.3	24	63	.133	.448	13	113	.078	.680	29	83	.179	.512
.3-.4	23	86	.127	.475	9	122	.054	.735	20	103	.123	.635
.4-.5	23	109	.127	.602	14	136	.084	.819	29	132	.179	.814
.5-.6	16	125	.088	.690	8	144	.048	.867	11	143	.068	.882
.6-.7	10	135	.055	.745	10	154	.060	.927	3	146	.018	.901
.7-.8	15	150	.083	.828	7	161	.042	.969	2	148	.012	.913
.8-.9	5	155	.028	.856	0	161	-	.969	2	150	.012	.925
.9-1.0	6	161	.033	.889	4	165	.024	.994	3	153	.018	.944
1.0-1.1	6	167	.033	.922	1	166	.006	1.000	0	153	-	.944
1.1-1.2	2	169	.011	.933					1	154	.006	.950
1.2-1.3	7	176	.038	.972					1	155	.006	.956
1.3-1.4	1	177	.005	.977					0	155	-	.956
1.4-1.5	2	179	.011	.989					2	157	.012	.969
1.5-1.6	1	180	.005	.994					1	158	.006	.975
1.6-1.7	0	180	-	.994					0	158	-	.975
1.7-1.8	0	180	-	.994					1	159	.006	.981
>1.8	1	181	.005	1.000					3	162	.018	1.000

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TABLE A.3.19

FREQUENCY DISTRIBUTION FOR THE PACIFIC OCEAN OUTSIDE THE 200 MILE ZONE

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	6	6	.018	.018	34	34	.104	.104	41	41	.123	.123
.1-.2	16	22	.049	.067	43	77	.132	.236	90	131	.270	.393
.2-.3	26	48	.080	.148	44	121	.135	.371	68	199	.204	.597
.3-.4	28	76	.086	.243	29	150	.089	.460	67	266	.201	.798
.4-.5	42	118	.121	.364	46	196	.141	.601	31	297	.093	.891
.5-.6	30	148	.092	.456	19	215	.058	.659	7	304	.021	.912
.6-.7	30	178	.092	.548	20	235	.061	.720	5	309	.015	.927
.7-.8	14	192	.043	.592	22	257	.067	.788	5	314	.015	.942
.8-.9	17	209	.052	.645	10	267	.031	.819	6	320	.018	.960
.9-1.0	20	229	.061	.706	17	284	.052	.871	1	321	.003	.963
1.0-1.1	26	255	.080	.787	10	294	.031	.902	3	324	.009	.972
1.1-1.2	12	267	.037	.824	3	297	.009	.911	1	325	.003	.975
1.2-1.3	16	283	.049	.873	9	306	.027	.938	0	325	-	.975
1.3-1.4	8	291	.025	.898	8	314	.024	.963	3	328	.009	.984
1.4-1.5	10	301	.031	.929	4	318	.012	.975	1	329	.003	.987
1.5-1.6	5	306	.015	.944	5	323	.015	.990	4	333	.012	1.000
1.6-1.7	7	313	.022	.966	3	326	.009	1.000				
1.7-1.8	2	315	.006	.972								
>1.8	9	324	.028	1.000								

TABLE A.3.20

FREQUENCY DISTRIBUTION FOR THE PACIFIC OCEAN WITHIN THE 200 MILE ZONE

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1	6	6	.039	.039	36	36	.259	.259	29	29	.215	.215
.1-.2	24	30	.155	.194	39	75	.280	.539	15	44	.111	.326
.2-.3	20	50	.130	.224	12	87	.086	.625	24	68	.177	.503
.3-.4	19	69	.123	.448	9	96	.065	.690	18	86	.133	.637
.4-.5	21	90	.136	.584	14	110	.101	.791	23	109	.170	.807
.5-.6	11	101	.071	.655	8	118	.057	.848	10	119	.074	.881
.6-.7	9	110	.058	.714	10	128	.072	.920	3	122	.022	.903
.7-.8	14	124	.091	.805	6	134	.043	.964	2	124	.015	.918
.8-.9	5	129	.032	.837	0	134	-	.964	0	124	-	.918
.9-1.0	6	135	.039	.876	4	138	.029	.993	2	126	.015	.933
1.0-1.1	5	140	.032	.909	1	139	.007	1.000	0	126	-	.933
1.1-1.2	2	142	.013	.922					1	127	.007	.940
1.2-1.3	7	149	.045	.967					1	128	.007	.947
1.3-1.4	1	150	.006	.974					0	128	-	.947
1.4-1.5	2	152	.013	.987					2	130	.015	.962
1.5-1.6	1	153	.006	.993					1	131	.007	.969
1.6-1.7	0	153	-	.993					0	131	-	.969
1.7-1.8	0	153	-	.993					1	132	.007	.977
>1.8	1	154	.006	1.000					3	135	.022	1.000

TABLE A.3.21

FREQUENCY DISTRIBUTION OF SAMPLES FROM THE SILICEOUS OOZES OF THE NORTH PACIFIC OCEAN

	Ni				Cu				Co			
Interval	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.	Freq.	Cum. Freq.	Rel. Freq.	Cum. Rel. Freq.
0-.1									2	2	.071	.071
.1-.2									9	11	.321	.393
.2-.3									14	25	.500	.893
.3-.4					3	3	.107	.107	3	28	.107	1.000
.4-.5	1	1	.036	.036	3	6	.107	.214				
.5-.6	3	4	.107	.143	0	6	-	.214				
.6-.7	1	5	.036	.179	3	9	.107	.321				
.7-.8	2	7	.071	.250	0	9	-	.321				
.8-.9	1	8	.036	.286	0	9	-	.221				
.9-1.0	1	9	.036	.321	4	13	.143	.464				
1.0-1.1	2	11	.071	.393	4	17	.143	.607				
1.1-1.2	2	13	.071	.464	0	0	-	.607				
1.2-1.3	5	18	.179	.643	3	20	.107	.714				
1.3-1.4	3	21	.107	.750	3	23	.107	.821				
1.4-1.5	0	21	-	.750	0	23	-	.821				
1.5-1.6	2	23	.071	.821	4	27	.143	.964				
1.6-1.7	1	24	.036	.857	1	28	.036	1.000				
1.7-1.8	1	25	.036	.893								
1.8-1.9	2	27	.071	.964								
≥1.9	1	28	.036	1.000								
