

PETROLEUM RESOURCES

UNDER THE
OCEAN FLOOR

NATIONAL PETROLEUM COUNCIL

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Prepared by the

National Petroleum Council
in response to a request from the
Department of the Interior

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UNDER THE
OCEAN FLOOR
March 1969

Prepared by
the National Petroleum Council's Committee
on Petroleum Resources Under the Ocean Floor
E. D. Brockett, Chairman

with the assistance of the

Technical Subcommittee on Petroleum Resources

Under the Ocean Floor

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CREDITS:

Front cover by Pierre Laporte Other photographs courtesy of: Standard Oil Company (N.J.)

Published in the United States of America in 1969 by the National Petroleum Council 1625 K Street, N.W., Washington, D.C. 20006

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Library of Congress Catalog Card Number: 71-85470

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Printed in the United States of America

PREFACE

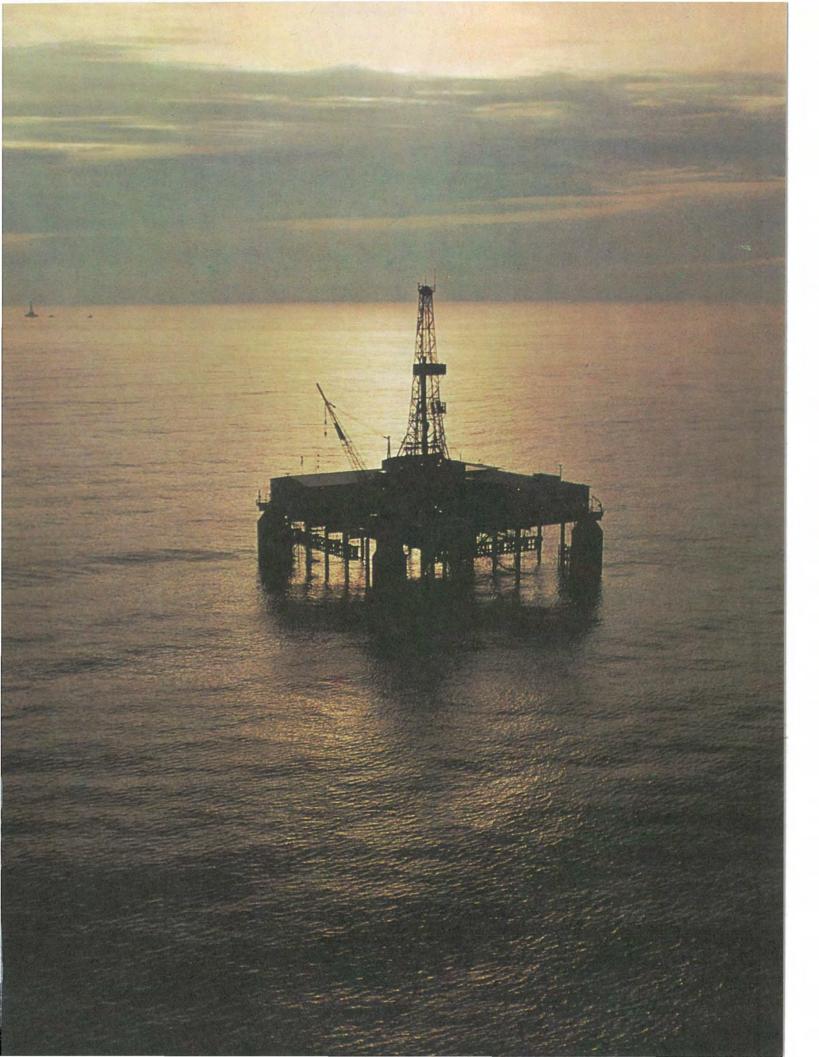
The National Petroleum Council, an industry advisory body representing virtually all sections of the U.S. oil and gas industries, was established by the Secretary of the Interior on June 18, 1946, pursuant to a directive of the President of the United States. The purpose of the Council is to advise, inform and make recommendations to the Secretary of the Interior with respect to matters relating to petroleum or the petroleum industry submitted to it by the Secretary.

This report, therefore, expresses the consensus of the membership of the National Petroleum Council. Association of representatives of the Department of the Interior and other government agencies with the deliberations of the Council on this subject does not connote endorsement of the recommendations expressed by the Council in this report. The views expressed in the report are those of the Council and do not necessarily reflect the views of the Department of the Interior or of the United States Government.

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INTRODUCTION

Science and technology are making the oceans of the world a rapidly expanding frontier, as President Johnson observed, and it is to the oceans, which cover approximately three-fourths of our globe and affect the destiny of all mankind, that we must now turn our attention in the quest for fuels, minerals and food.

Interest in the resources of the oceans has been particularly stimulated by the attention being given this subject by the General Assembly of the United Nations. In December 1967, the United Nations established an Ad Hoc Committee to study the scope and various aspects of the item entitled "Examination of the question of the 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 the use of their resources in the interests of mankind." The Ad Hoc Committee prepared and submitted a report in the Fall of 1968 which was considered by the 23rd session of the General Assembly. The First Committee recommended four resolutions which were adopted by the General Assembly on December 21, 1968, the principal resolution being the establishment of a permanent 42-state committee to continue the work of the Ad Hoc Committee.

The Federal Government has also been studying the various aspects of research into and development of the resources of the oceans. In this regard the Department of the Interior has primary responsibility for conservation of the Nation's mineral resources, and the administration of leasing laws in the management of such resources within the Federal domain.

The National Petroleum Council (NPC), as an officially constituted industry advisory body to the Secretary of the Interior on oil and gas matters, was requested to assist the Department of the Interior and other government agencies in formulating their posture toward the development of petroleum resources of the deep sea.³

A. The Specific Study Assignment

In the Interior Department's request letter dated January 24, 1968, the Council was asked to prepare a study which would consider:

- —whether the definition of the continental shelf⁴ is in keeping with technological advancements in offshore capability;
- —what type of regime would best assure the orderly development of the petroleum resources of the ocean floor and the time frame within which it might be implemented;
- —what type of regime is best designed to assure conservation of the resources and protection of the environment; and
- —any other points or comments deemed appropriate.

At a meeting of the NPC Agenda Committee, the Hon. J. Cordell Moore, then Assistant Secretary of the Interior for Mineral Resources, elaborated further, saying "the proposal which you have before you requesting that the National Petroleum Council undertake a study of certain problems relating to the exploitation of the deep sea is in essence a request by the Department of the Interior and the State Department to take the pulse of the oil industry which has a tremendous stake in the question."

The military establishment is, of course, highly dependent upon adequate petroleum supplies for its mobility, but beyond that aspect of the matter, the NPC naturally excluded from this report any discussion of military implications of seabed use.

B. Formation of the Study Group

At its meeting on January 25, 1968, the NPC unanimously agreed to undertake the study as requested by the Department of the Interior. To carry out its assignment, J. C. Donnell II, then NPC Chairman, with the approval of the Department of the Interior, established a 22-member Committee on Petroleum Resources Under the Ocean Floor. He designated E. D. Brockett, Chairman of the Board, Gulf Oil Corporation, as Chairman of this Committee. The Co-Chairman of the Committee was the Hon. J. Cordell Moore.

The Committee subsequently set up a working group to assist it—a Technical Subcommittee, composed of 18 members under the Chairmanship of Hollis D. Hedberg, Exploration Adviser, Gulf Oil Corporation.⁶

C. Interim Report (July 1968)

The Committee and its Subcommittee commenced a thorough study of all aspects of this broad problem in the Spring of 1968. Because of the deliberations of the U.N. Ad Hoc Committee on the Oceans. which started in March of that year, and studies being conducted by official U.S. groups, such as the Marine Sciences Commission, the Committee submitted, on an "urgency" basis, an interim report reflecting major conclusions and recommendations at the NPC meeting on July 9, 1968. The Council approved and adopted the Committee's report as presented by Chairman Brockett. The report was submitted to Secretary of the Interior Udall, and distributed to the State Department, other government agencies and the general public under the title Petroleum Resources Under the Ocean Floor: An Interim Report of the National Petroleum Council, July 9, 1968.

D. Relationships

In carrying out their assignments the Committee and Subcommittee benefited from close working relation-

^{1.} U.N. Report A/7230.

^{2.} U.N. Report A/7477 and Verbatim Record A/PV.1752.

^{3.} See Appendix A.

^{4.} Article I of the 1958 Convention on the Continental Shelf reads: "For the purpose of these articles, the term 'continental shelf' is used as referring (a) to the seabed and subsoil of the submarine areas adjacent to the coast but outside the area of the territorial sea, to a depth of 200 metres or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas; (b) to the seabed and subsoil of similar submarine areas adjacent to the coasts of islands." (Emphasis added.)

^{5.} See Appendix B.

^{6.} See Appendix C.

ships and consultations with key representatives of the State, Defense, Commerce and Interior Departments, as well as by exchanging views with certain members and staff personnel of the Marine Sciences Commission and the Marine Sciences Council. A staff member of the NPC was an informal observer with the U.S. delegation on the U.N. Ad Hoc Committee

on the Oceans at its sessions held at the U.N. Headquarters in New York and at the final session held in Rio de Janeiro, Brazil. Numerous consultations were also held by NPC Committee members with qualified experts in the academic and professional communities, as well as with experts in petroleum and other industry groups.

CHAPTER ONE—SUMMARY AND RECOMMENDATIONS

The National Petroleum Council, having given careful consideration to U.S. national energy policy objectives, and to the geological, technological, economic, and legal aspects inherent in the finding and developing of mineral resources under the ocean floor, has reached the major conclusions and recommendations set forth in this chapter.

United States Energy Requirements and National Objectives

1. The United States Is Dependent Upon Continuing Adequate and Secure Supplies of Energy

The demand for energy in the United States is growing rapidly. This increase results from growth of the population and the rise in per capita consumption of energy.

The U.S. population doubled in the last 50 years to about 200 million and by the year 2000 will approach 350 million.

Our gross national product and per capita consumption are first among nations and are closely related to the availability of energy and the amount we use. In 1950, the annual per capita utilization of all types of energy was equal to 39 barrels of oil; during the next 15 years this figure increased by 25 percent; and between 1965 and 1980, per capita use of all types of energy is expected to rise to the equivalent of 69 barrels of oil.

It is thus apparent that the general welfare and economy of this Nation are dependent upon continuing adequate supplies of energy at reasonable prices. Moreover, broad national security considerations demand that the largest possible share of these energy supplies remain within our control.

Because the projected future energy needs of the Nation are so great, we will be compelled to draw upon all feasible domestic sources—conventional sources of petroleum, oil shale, tar sands, coal, water power and fissionable materials—in order to satisfy these needs.

Petroleum, the Leading Source of Energy, Will Be Needed in Increasing Quantity Far into the Future

Oil and gas in 1967 supplied 75 percent of the overall energy requirements in the United States. In addition, petroleum serves as a major raw material source for organic chemicals, wax, asphalt, and other varieties of nonenergy needs.

Indicative of the growing need for oil is the anticipated doubling in the fuel requirements of the transportation industry during the period between 1965 and 1980. This overall growth is expected to increase aggregate daily demand by more than 5 million barrels of oil equivalent per day and will be supplied almost entirely by liquid petroleum products.

The combined expansion of all energy markets between 1965 and 1980 has been estimated to be the equivalent of almost 20 million barrels of oil per day.

It is inevitable that petroleum will continue to supply critically needed quantities of energy to meet these ever-growing national needs.

A Healthy and Expanding Domestic Petroleum Industry Is Essential to the Security of the United States and the Defense of the Free World

The future availability to the United States of adequate energy supplies is a matter of critical national importance. The essential role of petroleum for industrial and military strength has been repeatedly demonstrated in every national emergency since the turn of the century.

A domestic industry capable of delivering substantial increments of petroleum on short notice is a major asset and an essential requirement of the United States and its allies, many of which are heavily dependent on oil imports. The Middle East crisis of 1967 is a clear case in point. The domestic industry was then able, on short notice, to increase production in aid of Western European requirements.

At present, about one-fifth of the petroleum liquids consumed in this Nation is imported from other countries. But we cannot prudently come to rely excessively on foreign sources to meet our domestic needs. In the first place, our national security demands that the largest practicable domestic supplies be available. This requires the continuing active exploration for and discovery of new domestic hydrocarbon reserves within U.S. jurisdiction, whether on land or offshore. In the second place, the rapidly growing foreign demands for petroleum preclude the assumption that there will always be a surplus of foreign oil.

4. The Ratio of United States Reserves
to Production and the Rate of New
Discoveries on Land Are in a Declining
Trend. It Is Imperative That the United
States Government Take All Appropriate Measures Toward Assuring the
Availability of Additional Domestic
Reserves

Despite the significant role which domestic petroleum supplies must play in meeting U.S. requirements, and despite the fact that it is estimated that domestic demand for crude oil will rise by more than 50 percent between 1965 and 1980, nevertheless:

- —the ratio of new U.S. crude oil reserves to production on land has been in a declining trend since 1950; and
- —discoveries of domestic crude oil on land have lagged since 1957 and domestic exploration has significantly declined since 1955.

In view of the vital and indispensable contribution which petroleum must make to our national interest and security, it is fundamental that the U.S. Government take every reasonable and appropriate avenue open to it to assure that this Nation will have an adequate and secure supply of petroleum for the future.

Prospects of Petroleum Accumulations Under the Oceans

The Near Offshore is Already α Substantial and Growing Source of United States Petroleum

In 1946, the U.S. petroleum industry began significant drilling and producing operations in offshore areas of this Nation's coasts. The similarity in stratigraphy and structure to the pattern of onshore geology and the petroleum prospectiveness of the strata below the shallow near-shore coastal waters are already well established. Since 1946 more than 9,000 offshore wells have been drilled in these areas and offshore operations in 1967 accounted for almost 12 percent of the crude oil and about 10 percent of the natural gas production of the United States.

These operations have been exceedingly beneficial for this Nation. The submerged continent thus far investigated off U.S. coasts holds real promise of helping to meet the rapidly growing national petroleum needs. Indeed, as will be later indicated, a major promise of U.S. petroleum supplies for the future lies in the resources of the entire submerged portion of the continent extending from the coasts of the United States down to the abyssal ocean floor.

6. At This Time, Geological Knowledge of the Far Offshore Is Meager but the Ingredients for Potentially Commercial Accumulations of Petroleum Are Quite Certainly Present Under the Outer Shelf, Slope, and Rise of the Oceans and of the Semienclosed Seas

Unlike the shallow water near-shore portion of the continental shelf, the outer portions of the continental margins have undergone very little exploration. There is only a first approximation of the petroleum prospects of the outer shelf, the slope, and the rise. It is known, however, that sediment thicknesses are adequate and that there is a high probability of good source potential, reservoir beds and accumulation traps of promise. Available data even suggest that sediment volumes beneath the rises and slopes may be substantially larger than beneath the shelves. Recent drilling on one of the Sigsbee Knolls

in the Gulf of Mexico, in a water depth of 11,720 feet (3,572 meters), confirmed the presence of a salt dome structure and actually recovered oil-bearing cores from the cap rock. Many other semienclosed seas are known to have substantial sediment thicknesses and promising prospects.

7. Prospects of Significant Occurrences of Petroleum Under the Deep Oceans Can Be Neither Confirmed nor Ruled Out

The oceans cover an area of about 139 million square miles (360 million square kilometers), or more than 70 percent of the earth's surface. Experts have estimated that less than one-fifth of this ocean cover overlies the submerged continents; the remainder, including the abyssal plains, ridges, trenches, and other features of the deep-ocean floor, comprises an area about double the land surface of the globe.

Hydrocarbons occur in at least trace quantities in the sediments of almost all oceanic areas and the prospects of petroleum accumulation in some degree cannot be excluded from any of the ocean provinces. Present information suggests that over most of the deep-ocean basins there is a relatively thin sedimentary section and probably only scanty reservoir beds and relatively little folding. However, locally, even in these deep-ocean provinces, there are adequate sedimentary thicknesses and indications of favorable trap structure so that prospects cannot be foreclosed, although it is probable that accumulations will be far fewer per unit area in the deep oceans seaward of the continental margins.

Technological Capability of Industry for Petroleum Development of the Offshore Areas

 The Present Status of Offshore Technology Reflects Substantially Greater Water-Depth Capability for Exploration Than for Exploitation

Exploration capability (with controlled pressure and provision for reentry) will continue to considerably precede exploitation capability (with complete production system installation). The industry already is drilling exploratory wells in water as deep as 1,300 feet (396 meters).

Considerable basic research has been conducted in waters of the deep ocean, and geological surveys of various types can be carried out satisfactorily at all water depths. During the current Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) project, as of February 5, 1969, a total of 39 holes had been drilled of which 17 were in water depths of 15,000-18,000 feet (4,572-5,486 meters), though without means of hole reentry and with penetration depths limited by the life of a single bit. (The maximum penetration into the ocean floor attained thus far with this type of drilling in any one hole is 2,738 feet (835 meters) at a location in 16,316 feet (4,973 meters) of water giving a maximum total subsea level penetration to date of 19,054 feet [5,807 meters].)

 Within Less than Five Years, Technology Will Allow Drilling and Exploitation in Water Depths up to 1,500 Feet (457 Meters). Within Ten Years Technical Capability to Drill and Produce in Water Depths of 4,000-6,000 Feet (1,219-1,829 Meters) Will Probably Be Attained

Commercial production operations, except in a few special situations, have to date been performed only with above-water fixed platforms. These platforms have been installed in a maximum water depth of 340 feet (104 meters). Platform designs have been proposed for greater depths and their utilization appears practical for depths as great as 600 feet (183 meters).

A few underwater well completions have been made in depths of less than 300 feet (91 meters). In every case, however, the wells have been flowed to an above-surface production facility, either onshore or offshore.

Currently, several methods of remotely operating underwater wells and production facilities are being designed, developed and tested. Development of these could aid in accelerating the extension of exploitation capability beyond 600 feet (183 meters). Probably the most difficult roadblock in the application of such deepwater drilling and production systems is the testing and implementation of underwater and/or floating facilities for gathering and handling fluids.

In 1968, leases in 1,800 feet (549 meters) of water were purchased from the U.S. Government, and an exploratory well was drilled from a floating facility and successfully tested in 640 feet (195 meters) of water. An exploratory hole was similarly drilled in 994 feet (303 meters) of water but did

not secure production. One operator has drilled in 1,300 feet (396 meters) of water, penetrating to a subsoil depth in excess of 12,000 feet (3,657 meters).

The prospect of commercial petroleum accumulations in water depths or at locations beyond the capability of present techniques or facilities continues to be the principal motivation of the advancement of this technology. The innovations in technology have been frequent and industry has made prompt application of them in its operations when justified. In view of the extent of present research and engineering, it is reasonable to expect that a technical capability will be developed to provide a complete system for exploration and exploitation in water depths of at least 1,500 feet (457 meters) within the next 3 to 5 years and in water depths approximating 4,000-6,000 feet (1,219-1,829 meters) within the next decade, if warranted by economic factors.

Economics of Offshore Petroleum Exploration and Development

 Progress of Industry into Ever Deeper Waters Is Limited Primarily by Economic Attractiveness Rather than by Technological Capability

About 80 percent of the total domestic offshore oil supply is currently being produced from water depths of less than 100 feet (30 meters). Thus the advancement of petroleum production into deeper waters has been relatively slow. The reasons have been primarily economic.

Economic attractiveness of deeper water ventures will depend on many factors: the overall demand for petroleum; competition from land and shallow water areas; the relative cost and effectiveness of deep-marine production operations; the relative productivity of deep-marine petroleum deposits; and competition from oil shale, tar sands, coal and other energy sources. An attractive investment climate, including security of investment, is always a prerequisite.

11. Costs of Petroleum Operations Increase Rapidly with Increasing Water Depth and Distance from Shore

Analyses of offshore operations indicate that costs rise rapidly with increasing water depths and dis-

tances from shore; and in the deeper water of the continental shelf, costs on the average are already approaching marginal limits. Thus, as operations progress toward the edge of the continental shelf, only the very large, highly productive accumulations of petroleum will be economical to produce. It is estimated, for example, that the capital cost to develop and produce from a 50-million barrel model offshore field under existing conditions in the Gulf of Mexico will increase by more than 100 percent when moving from 100 to 600 feet (30 to 183 meters) of water.

Future technological innovations could improve the economics of deeper offshore operations, just as advancing technology could also decrease the cost of alternate nonconventional sources of petroleum supply, making them stronger competitors. Notwithstanding the probable long-range impact of competition from other sources of energy, it is probable that production from offshore petroleum accumulations, at least those at moderate depths and distances from shore, and having productivity characteristics comparable to the better fields onshore, will be competitive with other domestic sources for the foreseeable future. Indeed, such offshore petroleum accumulations will probably have to carry the burden of maintaining, for this Nation, a desirable balance between domestic and imported petroleum. Moreover, indications are that future U.S. energy requirements will be so heavy as to compel us to draw on all viable domestic energy sources.

Current National Iurisdiction Over Petroleum Resources of Oceanic Areas

12. Coastal-Nation Jurisdiction of Subsea Mineral Resources Does Not Affect High Seas Status of Overlying Waters

The recommendations advanced in this report are in full accord with preserving the character and freedom of the high seas under Articles 1 and 2 of the 1958 Geneva Convention on the High Seas. Article 3 of the 1958 Convention on the Continental Shelf restates the principle of the High Seas Convention and of general international law that the rights of coastal nations over resources of the seabed and subsoil do not affect the present legal status of the superjacent waters as high seas, or that of the airspace above those waters. Thus the Continental Shelf Convention and the High Seas Convention limit the capacity of coastal nations to assert claims of jurisdiction seaward of their internal waters and territorial seas which would impair freedom of the high seas or the water column above the continental shelf or abvssal ocean floor.

In asserting this Nation's claim to exclusive jurisdiction over the subsea resources of our submerged continent, and recognizing similar rights in all other coastal nations, the United States should affirm that its claim is in no way contrary to the status of the overlying waters as provided for in Article 3 of the Convention on the Continental Shelf as well as the Geneva Convention on the High Seas.

13. The United States and Other Coastal Nations Have Exclusive Sovereign Rights to Natural Resources Underlying the Seabed of the Entire Submerged Portion of the Continent Adjacent to Their Coasts

To date at least 107 nations have confirmed that the coastal state has mineral jurisdiction in submerged areas adjacent to its coasts. This confirmation has taken various forms including ratification of the Convention on the Continental Shelf, unilateral declaration, domestic legislation, offshore concession agreement, regional treaty or other national practice (see Appendix F). The seaward extent of the exclusive sovereign rights of the United States and other coastal nations to all submarine mineral resources is given specificity by the terms of the 1958 Geneva Convention on the Continental Shelf. Thirty-nine nations (35 of them coastal) are parties to this Convention, which was characterized by the report of the Senate Committee on Foreign Relations recommending ratification as converting "state practice into codified international law." 1

Article 1 of this treaty confirms to the coastal nation exclusive sovereign rights to the mineral resources of the seabed and subsoil thereof in "the submarine areas adjacent to the coast" out to water depths of 200 meters, and beyond that, "to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas."

Article 2 of the Convention provides that the rights of the coastal nations over the entirety of these areas are exclusive, "in the sense that if the coastal State does not explore the continental shelf or exploit its natural resources, no one may undertake these activities, or make a claim to the continental shelf, without the express consent of the coastal State."

^{1.} Senate Executive Report No. 5, 86th Cong., 2nd sess., p. 8.

In construing the language of this Convention, the National Petroleum Council concludes that the ultimate jurisdiction of the coastal nation with respect to mineral resources under the ocean floor clearly extends by virtue of the "exploitability" and "adjacency" criteria outward to encompass the submerged continent down to its junction with the abyssal ocean floor.2 The Convention's criterion of "adjacency" is a limitation upon the exploitability criterion which serves to exclude the abyssal ocean floor from the exclusive resource jurisdiction of the coastal nation, regardless of how "exploitable" the deposits seaward of the continental block might become. The drafters of the Convention also specifically intended, in fairness to the nations concerned, and used language sufficiently broad to provide that, where the continent drops abruptly to the abyssal ocean floor, their natural resource jurisdiction extends to the nearby portions of the deep ocean to the extent permitted by the dual criteria of exploitability and adjacency. This interpretation, both for the general and the special case, is supported by the findings of many qualified bodies which have studied the matter, by the history of the negotiation of the Convention, by its legislative history in the U.S. Senate, and by the subsequent practice of coastal nations, including the United States in granting concessions or leases in progressively deeper waters.

While the matter does not appear to have been specifically discussed in the preparatory works leading to the Convention, the language selected would also appear broad enough to permit the United States and other coastal nations, in appropriate cases, to claim natural resources jurisdiction to the median line of semienclosed seas, regardless of their depth, under the same twin criteria of exploitability and adjacency.

14. Geology Supports the Position that Coastal-Nation Jurisdiction Over Subsea Resources Should Extend to the Outer Boundary of the Submerged Continent

The surface of the earth, whether water covered, can be divided generally into two fundamentally distinct geomorphic units—the *ocean basins* and the *continental platforms*. These units are the surficial reflection of fundamental lateral geological differences in the character of the earth's crust down to the mantle. The continental crust differs from the

oceanic crust in (1) higher surface elevation, (2) greater depth to mantle, (3) greater thickness, (4) lesser density, (5) lower seismic velocity, and (6) more acidic rock composition.

The change from continental to oceanic crust is the most distinctive recognizable lateral change in the earth's lithologic character. Viewed on a world scale it is impressively sharp. This is true even though locally and in detail the change often appears to take place through a transition zone or indeterminate zone many kilometers or even hundreds of kilometers wide, and many of the distinguishing features are determinable in detail only approximately and only by means of subsurface geophysical measurements.

The principal reflection at the surface of the fundamental change from continental to oceanic crust is the topographic scarp known as the continental slope, resulting from the isostatic effect tending to make the continental masses stand high relative to the adjacent oceanic areas.

The continental slope has been termed "by far the steepest, longest, and highest topographic feature on the earth's surface." The continental slope is the frontal edge of the submerged continent; and the base of the continental slope, coinciding approximately with the outer limits of the continental crust, constitutes the most distinct, the most profoundly significant, and the only natural surface feature which can be used as a guideline to the outer limits of the continent. Hence, it is a logical starting point for localizing the approximate outer limit of coastal-state jurisdiction.

However, even the base of the slope cannot be defined sharply enough to serve as a boundary of mineral resources jurisdiction in itself, and it should be used only as a guideline to a more precise boundary. Moreover, it should be emphasized that where continental rises are developed adjacent to the continental slope, the sediments of these rises will overlap the lower part of the slope so that the true boundary marking the outer limits of the continental block must be drawn to include not only the slope but also the landward portion of the rise.

A boundary so placed, to coincide as closely as possible with the true outer limit of the submerged continent, is in keeping with the scientific, as well as the legal, political, and economic realities, and gives appropriate recognition to the natural oceanward extension of the mineral resources domain of each coastal nation, and to the inclusion under its jurisdiction of the subsea resources over which it is most practically suited to exercise control. Suggestions for the practical application of this general principle are set forth in Conclusion 16.

This conclusion finds support in the rationale of the Judgment issued on February 20, 1969, by the International Court of Justice in the North Sea Continental Shelf Cases.

Implementation of United States Policy Objectives Consistent With the 1958 Convention on the Continental Shelf

15. The United States is Urged to Assert Promptly and Forthrightly Its Exclusive Jurisdiction Over the Mineral Resources of the Entire Submerged Portion of the Continent Off Its Shores

The 1958 Convention on the Continental Shelf clearly confirmed the rights of the United States, and other coastal nations, to jurisdiction of the seabed and subsoil mineral resources of the submerged portion of the continent adjacent to their shores. Thus this jurisdiction extends over the continental shelf, the continental slope, and at least the landward portion of the continental rise. The United States should promptly and forthrightly assert these rights, while recognizing similar rights of other coastal nations. Not to do so—in the light of our present and future energy needs—is risking our vital national interests and security and that of our allies as well.

Certainly no consideration should be given to the relinquishment of any of our legitimate rights to offshore areas confirmed to the United States by the Convention on the Continental Shelf. The petroleum potential of this submerged region is largely unknown, but in many areas it may be substantial. If it is, then the region is of critical importance with respect to this Nation's future energy requirements. Any attempt now to restrict the area of U.S. mineral jurisdiction to less than that already recognized under the Geneva Convention would be patently a needless and dangerous give-away of a vital segment of the American mineral estate, which this Nation cannot afford to relinquish.

It is desirable that the United States and other parties to the 1958 Convention, with such additional nations as care to join them, promulgate parallel uniform declarations along the lines recommended herein, stating the extent of their rights (and the limitations on those rights) under the 1958 Convention on the Continental Shelf.

16. Precise Demarcation of the Outer Boundary of Coastal-State Mineral Resource Jurisdiction Will Eventually be Needed

The general guideline to the seaward limit of coastalstate jurisdiction over seabed and subsoil resources has been defined previously as the outer edge of the submerged continental mass. This either falls at the base of the continental slope or extends to such distance beyond the base as is necessary to allow for overlap of the slope by the landward part of the continental rise where a continental rise is present. As already stated, however, the reduction of this general guideline to precise and readily identifiable boundaries might be subject to numerous disputes which could be largely resolved by the work of a competent technical agency created by the adherents to the Geneva Convention and such other nations as might wish to join them.

One possible approach that such an agency might take would be to establish a formula for application of the general guideline of the Geneva Convention under which boundaries would be drawn by each coastal nation in the form of straight lines connecting points fixed by coordinates of latitude and longitude within an agreed maximum distance oceanward from the base of the continental slope. The drawing of boundaries purely on depth contours or distances from shore should be avoided since such criteria are not only unsuitable for designating precise boundaries but also lack any consistent relation to more fundamental guidelines such as the edge of the continent. Thus, a 200-meter water-depth boundary would bear little relation to any natural submarine feature (even the edge of the continental shelf) and a recently proposed 2,500-meter water-depth boundary would fall beyond the base of the slope in some areas, would lie halfway up the slope in others, and would lose to the coastal state the whole continental rise almost everywhere, plus much of the continental slope in many places. Special situations involving precipitously dropping continental margins and islands are discussed in chapter 7.

Pending more precise demarcation, a desirable interim step would be for the United States and other coastal nations to prepare maps indicating to the best of present scientific knowledge a zone coinciding with the approximate edge of the submerged continental mass adjacent to their coasts.

Regime Over Oceanic Areas Beyond Limits of Exclusive National Resource Jurisdiction

17. Existing Principles of International Law are Adequate to Govern Petroleum Exploration and Exploitation on the Abyssal Ocean Floor for Some Time To Come

Beyond the bounds of national sovereignty and the

The landward portion of the continental rise commonly overlaps the submerged edge of the continental block, i.e., continental mass.

limits of exclusive coastal-nation jurisdiction over subsea mineral resources lie the deeper or more remote oceanic areas constituting more than 80 percent of the total ocean-covered area of the world.

International law imposes no prohibition upon the freedom of a state or its nationals to explore or exploit the resources of the bed of the high seas, if this freedom is exercised with reasonable regard for the interests of other states in their exercise of high-seas freedoms. Although general rules of international law may not be sufficiently detailed to provide the necessary certainty for long-range mineral exploitation in this deep-ocean region, these rules will constitute the legal framework for any introductory activity that may occur for some years to come.

 Long-Term Arrangements Concerning Resources of the Seabed of Mid-Oceanic Areas Should Reflect Policies Which Will Encourage, Not Deter, Exploration, Recovery, and Use of Deep-Ocean Minerals

Even though existing international legal principles are sufficient to govern preliminary deep-seabed activities, national regulation in matters of state jurisdiction and national consideration of long-term arrangements concerning the seabed should reflect policies which will encourage rather than deter production, recovery, and use of deep-ocean minerals. These include policy objectives such as (a) encouraging exploration for and production of resources at reasonable consumer cost consistent with a fair return to the investor; (b) encouraging maximum efficient recovery through the use of proper conservation practices; (c) facilitating responsible mineral development on a nondiscriminatory basis; and (d) reconciling competing uses of the environment and minimizing adverse effect of mineral operations on that environment.

In harmonizing competing uses in deep-ocean areas, each use should be considered upon its own merit and significance, and no particular use should be considered as having any *per se* priority over another use.

19. Adequate Knowledge of Deep Oceans is a Prerequisite to Determining Optimum Arrangements for Long-Range Oceanic Development

As previously indicated, it is believed that the greatest immediate interest in offshore petroleum activity will be in areas now under the exclusive mineral jurisdiction of the coastal nations. Thus the assurance that the seaward limits of rights now possessed by coastal nations will continue to be respected is of major current concern to the nations of the world. Over 80 percent of these are coastal states.

Nevertheless, it is appropriate to appraise alternatives as to how exploratory or exploitative activity in deep-ocean areas beyond coastal-state jurisdiction should be legally structured. In this regard there is an inadequacy of knowledge about the natural resources and environment of the deep-ocean floor. Much more information and data will be required before realistic arrangements can be concluded for the promotion of long-range development. Therefore, the National Petroleum Council fully endorses the concept of the International Decade of Ocean Exploration, cooperative international research on the resources of the deep-ocean floor, and cooperative international study leading toward an eventual decision on the most appropriate and effective arrangements it vast area.

Meanwhile, present consideration regarding legal arrangements for deep-ocean areas could well be focused upon the formulation of standards of conduct for individual nations and persons engaging in activity pursuant to national license.

A step which might follow would be the establishment of an international registry, to serve as a public record of exploratory activity. It seems premature to move toward the establishment of an international agency with licensing authority.

Relations Between the Petroleum Industry and Other Users of the Oceans and Seabeds; Pollution Control, Conservation and Research

20. Interference with Other Users of the Deep Oceans Created by Petroleum Exploitation Activities Will Be Minimal

As exploration and development of petroleum resources is extended further into deeper waters, some degree of interference is likely to develop with the use by others of the high seas, the water column, and the underlying seabed. However, because of the vastness of the oceans and the greater divergence of traffic and other potential conflicting uses, such problems can be expected to be fewer than those encountered currently in near-shore areas.

There exists a body of international rules for the resolution of conflicts among users of the oceans. Where operations are extensive, such as in the Gulf of Mexico, cooperation between the government and commercial users has resulted in establishment of

navigation "fairways." Freedom of navigation is thereby provided without unreasonable restraints on multiple user interests. Similar procedures might be employed for interferences in the deep sea, though interferences are likely to be remote.

CONCLUSION

It is the firm and carefully considered conclusion of the National Petroleum Council, an industry advisory body to the Secretary of the Interior, representing virtually the entire American oil and gas industries, that the United States, in common with other coastal nations, now has exclusive jurisdiction over the natural resources of the submerged continental mass seaward to where the submerged portion of that mass meets the abyssal ocean floor and that it should declare its rights accordingly. We believe that this was the intent of the framers and delegates who composed the 1958 Geneva Convention on the Continental Shelf. We believe that this was the understanding of the Congress and of the President of the United States when this country ratified the Geneva

Convention. We are convinced that this interpretation is in the best interests of this Nation, whether or not it is in the best interest of the American oil and gas industries.

This matter is extremely vital and involves basic principles and long-range implications concerning the well-being of this Nation and of all its people. The National Petroleum Council feels that it has a continuing responsibility to emphasize, as it has from time to time in the past, that adequate petroleum resources and the requisite conditions for their development are of major consequence to the economy and the security (in its broadest sense) of this Nation. The resources of this country, which do indeed include the resources of that part of our continent beneath the waters, are a great and priceless heritage. The oil and gas resources in these submerged portions of our continent may well prove to be larger than those remaining on the land. These strategic and valuable resources could well be the means of maintaining far into the future this Nation's essential self-sufficiency and avoiding the vulnerability inherent in dependence on foreign energy sources.

CHAPTER TWO—UNITED STATES ENERGY REQUIREMENTS AND NATIONAL OBJECTIVES

A. Energy

1. Relationships

The United States is blessed with a wealth of energy resources and with the capital and technology to develop them. Yet these resources and capabilities are finite in quantity. The potential demand for energy, on the other hand, does not yet have discernible limits. Therefore, the wise utilization of all of the energy resources under the jurisdiction of the United States, wherever they may be situated, is imperative. In 1790, the population of the United States was 3.9 million; today it is about 200 million; and by the year 2000 it will approach 350 million. The average annual energy consumption per person in the United States has risen from 39 barrels of oil (or the equivalent) in 1950 to 49 barrels of oil (or the equivalent) in 1965 and is expected to rise to the equivalent of 69 barrels of oil by 1980.1

Similarly, the energy demands of the free-world

Outlook for Energy in the United States, (New York: Chase Manhattan Bank), October 1968, pp. 10-11.

nations are soaring as these areas not only become more populated, but become more industrialized and step up the pace of their economic activity. This trend may be expected to continue since the population of the world, which was about 3.1 billion in 1965, is expected to double by the year 2000, to a total of 6 billion.

Oil and gas resources supply three-fourths of all the U.S. energy requirements. Looking very far into the future, it might be suggested that the emphasis on the form of energy needed is not relevant because, given enough time, it is reasonable to anticipate, in the light of past scientific advances, that adjustments can be made to accommodate almost any form of energy to almost any application. However, the economic life of energy extraction and conversion equipment and energy distribution systems is such that large-scale shifts from one form of energy to another take a long time to accomplish. Accordingly, the present energy use patterns which exist in this country today will generally continue for many years into the future.

2. Petroleum's Position in Energy Market

a) Demand—The value of crude petroleum production exceeds that of any other mineral produced in the Nation. In 1967, the total value at the well of crude oil produced was \$9.4 billion. The total value of all petroleum production, including natural gas and natural gas liquids, amounted to \$13.5 billion, or 59 percent of the total value of all mineral production in the United States.³

Petroleum's large share of the energy market will continue for the foreseeable future. A recent report by the Department of the Interior indicates, for example, that the amount of energy which will have to be supplied by petroleum will increase by approximately 50 percent between 1965 and 1980, though its total share of the energy market will decrease very slightly.⁴

b) Supply—Looking at domestic petroleum supplies, production increased between 1945 and 1965 by more than 75 percent for petroleum liquids and some 300 percent for natural gas. The relation of proved reserves to annual production in 1965 remained relatively constant at about 12:1 for crude oil and natural gas liquids, but decreased for natural gas from over 30:1 down to about 18:1.

The changes since 1945 in the principal components of U.S. petroleum supply used for energy are summarized as follows:

Table 1—Components of U.S. Petroleum Supply for Energy Uses

(Thousand Barrels Daily)

1945	1965	PERCENT CHANGE 1965 OVER 1945	PERCENT OF TOTAL IN 1965
U.S. Crude Oil 4,695	7,804	66.22	39.98
Gas Liquids 315	1,210	284.13	6.20
U.S. Natural Gas 1,977	8,039	306.63	41.18
Domestic Supply 6,987	17,053	144.67	87.36
Imports Residual			
Fuel Oil 86	944	997.67	4.84
Crude & Other 225	1,523	576.89	7.80
Total Imports 311	2,467	693.25	12.64
Total Supply 7,298	19,520	167.47	100.00

a-Expressed in terms of crude oil equivalents.

Source: NPC, Factors Affecting U.S. Exploration, Development and Production, 1946-1965, (Washington, D.C., 1967), p. 7.

> This tabulation shows that imports of petroleum increased from 4.3 percent of the total petroleum supply in 1945 to 12.6 percent in 1965. The rapid expansion of imports after World War II coupled with the decline in domestic exploration and drilling since 1956 led the United States to impose mandatory import controls in 1959 in an effort to maintain a healthy domestic petroleum industry for national security reasons. Through these import controls and the proration of production in certain areas of the country, a "standby" or reserve crude oil producing capacity was developed. However, it is apparent that this standby capacity is declining as domestic demand increases and imports' share of the total supply remains relatively constant. If this trend continues, the reserve-producing capacity could disappear in the 1970's.

While it might occur that ample sources of foreign petroleum will alleviate any imbalance in this Nation's supply situation, a note of caution is suggested. It is true that imports of petroleum could be increased beyond present allowable levels and at prices that are competitive. In 1967, the free world's proved reserve-to-production ratio for crude oil was about 50:1 as compared to the U.S. ratio of some 10:1. But while

From "Remarks of Hon. J. Cordell Moore," Asst. Secretary, Mineral Resources, U.S. Department of the Interior, (delivered before the Meeting of the National Petroleum Council, Washington, D. C., July 9, 1968).

^{3.} Based on data from U.S. Bureau of Mines.

United States Petroleum Through 1980, (Washington, D.C.: U.S. Department of the Interior, 1968).

the free foreign supply picture looks healthy now, the energy demands of free-world nations have been soaring as these areas become more populous and industrialized.

It seems likely that for the foreseeable future there will be sufficient foreign free-world capacity to export to the United States a much larger share of the domestic supply than at present. On the other hand, it has been determined as a matter of national policy that excessive dependence on foreign sources of petroleum at the expense of adequate development of domestic petroleum resources is against national security interests.

Since the discovery of oil in Pennsylvania in 1859, a total of more than 2,105,000 wells have been drilled in the search for oil and gas reserves in the United States. These wells were successful in finding a total of 133 billion barrels of liquid petroleum reserves and 585 trillion cubic feet of natural gas. Since that time, a total of 93 billion barrels of petroleum and 292 trillion cubic feet of natural gas have been produced, leaving proved hydrocarbon reserves in the United States at the end of 1967 at 40 billion barrels of liquid petroleum and 293 trillion cubic feet of natural gas.

In the report *United States Petroleum Through 1980*, the Department of the Interior developed its estimate that the requirement for new or additional domestic reserves of liquid hydrocarbons, to be obtained from discovery and increased recovery, is 67.5 billion barrels during the 15-year period 1966-1980.

Appendix D shows domestic demand estimates developed by Resources for the Future, Inc. (RFF)—extending to the year 2000.5 The Department of the Interior estimate tracks between the medium and high RFF projections during 1970-1980. If one assumes that 80 percent of the demand requirement would be supplied by domestic production, and that a crude oil reserve-toproduction ratio of 10:1 would be the acceptable margin of safety at the end of the century, then new discovery requirements during the 1981-2000 period would amount to at least 118 billion barrels, and might amount to 293 billion barrels. The median, 179 billion, represents a quantity of new reserves required to be discovered during

the period 1981-2000. By adding to this median requirement for 1981-2000 the 67.5 billion barrels estimated by the Department of the Interior for 1966-1980, there is an indicated need for about 247 billion barrels of gross additions to reserves during the 35-year period 1966-2000. This is about 1¾ times the total oil found and proved recoverable in the United States through 1965.

c) Potential—By contrast, the supply/demand projection made in the recent Interior Department survey of United States Petroleum Through 1980 indicates that the domestic oil industry is unlikely to replace as much crude oil in its reserves as it will withdraw for use between 1965 and 1980. In commenting on these findings, former Secretary of the Interior, Stewart L. Udall, made the following statement:

"The implications of this imbalance are for a gradual deterioration in the nation's capabilities to supply itself with crude oil. No precipitate, near-term crisis is in prospect, and the deficits could go on accumulating for several years. But it is clear that sooner or later the account must be balanced; no industry can go on indefinitely shortening its stocks in the face of a steadily rising demand for its products." ⁶

But he qualified his remarks, indicating that obviously any projections of future trends in discoveries and reserve additions is only as good as our knowledge about our present reserve position and the results of discovery activity over the recent past.

This qualification is particularly apropos when considering the potential of resources underlying the submerged portion of this continent, where a promising future can already be seen for commercial development in the shallow waters of the continental shelf.

d) Offshore Potential—Methods for drilling and producing in offshore waters of the United States have been developed entirely since 1946. These have been very important technological factors affecting exploration and production during the 20-year period. To date more than 9,000 wells have

Landsberg, Fischman, and Fisher, Resources in America's Future, (1963), pp. 848-853.

From "Remarks of Hon. Stewart L. Udall," Secretary of the Interior, (delivered before the Meeting of the National Petroleum Council, Washington, D. C., July 9, 1968).

been drilled offshore, and in 1968 offshore wells accounted for about 12 percent of the oil and 10 percent of the gas production in the United States.

At the time of this report, the U.S. petroleum industry has begun testing the new offshore leases it acquired in 1967-68 from the Federal Government involving three sales covering an aggregate of 1,650,000 acres. This equals 40 percent of the total amount of outer continental shelf acreage held under previous oil and gas leases as of January 1, 1967.

Oil and gas have been found on the submerged lands off Alaska, California, Louisiana and Texas. Exploration continues in other areas. Accordingly, any quantification of the petroleum potential in these submerged continental provinces would be purely speculative at this time. It is sufficient to say that it is entirely possible that large discoveries may be made on any portion of the submerged U.S. continental land mass not proved geologically impossible for petroleum accumulations. In 1968, leases were purchased in 1.800 feet (549 meters) of water, and an exploratory well was drilled and successfully tested in 640 feet (195 meters) of water. Commercial oil and gas production has been established in water depths of 340 feet (104 meters). An exploratory hole was drilled in 994 feet (303 meters) of water in 1968 but did not obtain production. As this report is written, one operator is currently drilling in 1,300 feet (396 meters) of water.

The analyses of offshore operations, included in chapter 5 of this report, indicate that capital and operating costs rise rapidly with increasing water depths and distances from shore. Thus, as operations progress toward the edge of the continental shelf, only the very large, highly productive accumulations of petroleum appear at this time to be economical to produce. The exploration of deepwater areas, therefore, is motivated by the potential presence of large fields and by the need to replace reserves being depleted in existing fields onshore.

Aside from national security considerations, the chief determinant as to how extensively or at what depths offshore petroleum ventures will be undertaken is the unit cost and profitability of the potential production from them. Programs with satisfactory returns will be pursued vigorously, while submarginal ventures will wait until such time as they may be competitive with alternate sources of petroleum or other energy resources.

3. Competing Energy Sources

Oil and gas now supply a large share of the energy market because they are both convenient fuels and are competitive with, or better than, that of other energy sources in the free market. This competition for the energy market will continue and such sources as nuclear power, coal and petroleum processed from oil shale and coal, will all find their place in the market as the economics of the market dictate. Offshore petroleum resources must be developed within the limits of this competition.

However, the increase in domestic demand for energy will be so great that nearly every source of supply that can be currently envisioned will almost certainly be needed sometime between now and the year 2000.

The challenge to the energy industries and the government, therefore, is to provide for the most timely and economic development of these resources for public use.

B. National Objectives

A stated national objective relating to energy is to assure a secure, adequate supply in the various forms required at the lowest cost commensurate with other national objectives. To foster such a goal, government acts to provide a political and economic climate in which private businessmen and corporations are encouraged to compete for the privilege of supplying energy in the quantity and form needed by this Nation.⁷

National interest in petroleum affairs, therefore, reflects appreciation of many important factors. Outstanding among these are the strategic role of oil and gas for national security, the need for conservation of these resources, and the vital contribution of petroleum in promoting economic progress.

In 1966, the NPC, at the request of Government, presented its considered judgment on sound petroleum policies for this Nation.⁸ It stated that the fundamental objective of public policies dealing separately with petroleum should be to serve the general welfare by:

^{7.} See footnote 4.

NPC, Petroleum Policies for the United States, (Washington, D. C., 1966).

- assuring adequate supplies of oil and gas for national security;
- encouraging ample supplies at reasonable prices for economic progress; and
- -promoting efficiency in all operations.

In its statement, the Council emphasized that a healthy and expanding domestic petroleum industry continues to be essential to the security of the United States and the defense of the free world. The essential role of petroleum for industrial and military strength has, indeed, been demonstrated repeatedly in every national emergency since the turn of the century.

The importance of having available adequate domestic petroleum for emergency and defense requirements was made apparent by the Middle East crisis of 1967, when a large portion of this energy resource in that part of the world became unavailable for political reasons. (The Middle East is the home of 67 percent of the free world's proved petroleum reserves.) Instead of suffering the supply shortages experienced by some countries, the United States was able to expand its own production by about 1 million barrels daily to help meet the needs of allied nations during the crisis.

CHAPTER THREE—PROSPECTS OF PETROLEUM ACCUMULATIONS UNDER THE OCEANS

A. Introduction

In evaluating the many interrelated problems of developing petroleum resources under the oceans, one of the first and most basic questions concerns how far out and to what depths in the ocean are there likely to be commercial accumulations of petroleum.

The most landward portion of the continental margin (the near-shore continental shelf) has already been explored for petroleum in many parts of the world and its similarity in stratigraphy and structure to the pattern of onshore geology and the fact that it is highly prospective for oil production are quite well established. On the other hand, the outer portions of the continental margin are not at all well explored. However, what is known suggests that they, too, have many of the characteristics requisite to

The usage in this report of terms for certain geologic and geomorphic features of the oceanic areas is discussed in the Glossary. Throughout the report "continental shelf" is used in its conventional geomorphic sense, unless reference is being made to the continental shelf as artificially defined in the 1958 Geneva Convention. In this event the expression "legal continental shelf" is used.

accumulation of significant quantities of petroleum.

This chapter does not discuss the potential of the landward portion of the area (the geological continental shelf) but briefly surveys the potential of the outer part of the continental margin (the continental slope and the continental rise) as well as the potential of ocean basins with their associated features (including oceanic trenches, ridges, and rises). Present knowledge concerning the submerged outer portions of the continents and the ocean basins, although growing rapidly, is still quite limited. There is at present only a first approximation of the nature of the outer shelf, the slope, the rise 2 and the ocean basins and trenches.3 Hydrocarbons probably occur in at least trace quantities in the sediments of almost all areas of the oceans. However, the prospects of the occurrence of significant quantities of petroleum in the deep-ocean sediments can neither be confirmed nor ruled out at this time. Current information does suggest, however, that commercial accumulations will be far fewer per unit area beyond the continental margins.

This latter conclusion as regards petroleum is also supported by the findings of the U.N. Ad Hoc Committee on the Oceans.4

B. The Great Ocean Basins, Oceanic Plains, Ridges, and Trenches

The oceans cover an area of about 139 million square miles (360 million square kilometers), or 71 percent of the earth's surface. A little less than a fifth of this ocean cover overlies the submerged continents; the remainder, including the abyssal plains, ridges, trenches, and other features of the deep-ocean floor, comprises an area approximately double the land surface of the globe.5 In the great ocean basins (the Pacific, Atlantic, and Indian) beyond the continental margins, the sedimentary column seems for the most part to be relatively thin (figure 1A), averaging only 0.5 to 1.0 km. of undisputed sediments (velocity 1.5 to 2.5 km./sec.) or a maximum of 2-3 km. if the second velocity layer (4.5 to 5.5 km./sec.) is assumed also to be sediment." In the North Atlantic the abyssal plains off the eastern United States have sediment thicknesses of a little over a kilometer landward, but this decreases to less than 0.5 km. at the seaward edge of the plain. For about two-thirds of the North Atlantic, over the broad area of the midoceanic ridges, sediment thicknesses vary from zero to a few hundred meters. A line drawn along the axis of maximum water depth approximately separates the edge of the continental sediment apron from this mid-ocean area of little or no sediment.

Adjacent to some of the oceanic island (figure 1B). island arcs (figure 1C), and in the deep trenches (figure 1D), sediment thicknesses range from several hundred meters to several kilometers.7

Sands are widespread in the abyssal plains of the Atlantic,8 distributed either by turbidity currents 9 or deep-sea currents.10 These sands are coarsest nearest the continental rise. Toward the seaward edge of the abyssal plains, they become fine-to-very-fine grained and make up only a small part of the deep-sea sediments which consist predominantly of pelagic clays and calcareous siliceous lutites rich in plank-

2. A. Guilcher, "Continental Shelf and Slope (Continental Margin)," The Sea, ed. M. N. Hill, vol. 3, (New York-London: John Wiley, 1963), pp. 281-311.

W. H. Poole, ed., "Continental Margins and Island Arcs," Geol. Survey of Canada Paper 66-15, (Ottawa, Canada, 1966), 486 pp. J. L. Worzel, "Deep Structure of Coastal Margins and Mid-Oceanic Ridges," Proceedings of 17th Symposium of Colston Research Society of Great Britain, vol. 17, (London: Butterworths, 1965), pp. 335-61.

and J. C. Harrison, "Gravity at Sea," The Sea, op. cit., pp. 134-74.

3. J. Ewing and M. Ewing, "Seismic Refraction Measurements in the Atlantic Ocean Basins, in the Mediterranean Sea, on the Mid-Atlantic Ridge, and in the Norwegian Sea," Bull. Geol. Soc. of Amer., vol. 70 (1959), pp. 291-318.

B. C. Heezen, M. Tharp, and M. Ewing, "The Floors of the Gceans: I. The North Atlantic," Geol. Soc. of Amer. Spec, Paper 65 (1959), 122 pp.

M. N. Hill, ed., "Ideas and Observations on Progress in the Study of the Seas," The Sea, op. cit., 963 pp.

H. W. Menard, Marine Geology of the Pacific, (New York: McGraw-Hill, 1964), 271 pp.

"Transitional Types of Crust Under Small Ocean Basins," Jour. Geophys. Research, vol. 72 (1967), pp. 3061-73.

G. P. Woollard, "Crustal Structure Beneath Oceanic Islands," Proc. Roy. Soc. of London, vol. 222, Ser. A., (1954), pp. 361-87.

4. United Nations Report A/7230, ±6(B) and 7, (1968), pp. 23-24.

5. H. W. Menard and S. M. Smith, "Hypsometry of Ocean Basin Provinces," Jour. Geophys. Research, vol. 71 (1966), pp. 4305-25.

6. M. Ewing and J. Ewing, "Distribution of Oceanic Sediments," Studies on Oceanography, (Tokyo, Japan: Geophys. Inst. Univ., 1964), pp. 525-37.

7. W. A. Anikouchine and Ling Hsin-Yi, "Evidence for Turbidite Accumulations in Trenches in the Indo-Pacific Region," Marine Geology, vol. 5 (1967), pp. 141-54.

J. R. Conally and M. Ewing, "Sedimentation in the Puerto Rico Trench," Jour. Sed. Petrology, vol. 37 (1967), pp. 44-59. R. L. Fisher and H. H. Hess, "Trenches," The Sea, op. cit., pp.

411-36.

W. J. Ludwig et al., "Sediments and Structure of the Japan Trench," Jour. Geophys. Research, vol. 71 (1966), pp. 2121-37. L. A. Weeks, R. N. Harbison, and G. Peter, "Island Arc System in Andaman Sea," Bull. Amer. Assoc. Petro. Geol., vol. 51 (1967), pp. 1803-15.

8. J. F. Hubert, "Dispersal Patterns of Pleistocene Sands on the North Atlantic Deep-Sea Floor," Science, vol. 136 (1962), pp.

and W. J. Neal, "Mineral Composition and Dispersal Patterns of Deep-Sea Sands in the Western North Atlantic Petrologic Province," Bull. Geol. Soc. of Amer., vol. 78 (1967), pp. 749-72.

9. M. Ewing et al., "Exploration of the Northwest Atlantic Mid-Ocean Canyon," Bull. Geol. Soc. of Amer., vol. 64 (1953), pp.

B. C. Heezen, "Turbidity Currents," The Sea, op. cit., pp. 742-75. and M. Ewing, "Turbidity Currents and Submarine Slumps and the 1929 Grand Banks Earthquake," Amer. Jour. Sci., vol. 250 (1952), pp. 849-73.

- and C. Hollister, "Deep-Sea Current Evidence from Abyssal Sediments," Marine Geology, vol. 1 (1964), pp. 141-74.

tonic remains.¹¹ On the landward side of the North Atlantic abyssal plains, where deep-oceans sediments have been most extensively studied, sands make up more than half the total thickness of the samples examined. In this area, Heezen has observed individual graded sand beds up to 3 meters thick.¹²

There is apparently little evidence of tectonically folded structure in sediments over the ocean floors. Ewing and Ewing have concluded from a study of seismic profiles for the Atlantic oceanic basins that "except in certain local areas, these sediment beds have undergone very little distortion since their deposition. This indicates that crustal deformation has been mainly confined to gentle warping during the entire period of deposition." In this connection we understand that the JOIDES deep sea drilling project (mentioned further in chapter 4) in one of its holes drilled northeast of the Bahamas in water depths of more than 17,000 feet (5,181 meters) recorded apparent dips of 5° to 15°. 14

In summary, over most of the deep-ocean basins, present information suggests a relatively thin sedimentary section (even the thickest parts of the abyssal plains are probably, with few exceptions, 2 km. or less), minimum reservoir beds, and relatively little folding. Although source potential of abyssal sediments is not considered unfavorable, ¹⁵ it is considered less favorable than for sediments of the continental slope and continental rise. This, with other factors already noted, would tend to downgrade the petroleum potential of the great ocean basins.

C. Semienclosed Seas

Along the margins of the main ocean basins and isolated from them are a large number of semienclosed seas, such as the North Sea, Black Sea, Hudson Bay, Okhotsk Sea, and Java Sea, which are more or less enclosed by land. While many of these are of shallow depth and clearly belong to the continental domain, others are characterized by great depths and oceanic crust, or are intermediate in character between oceanic and continental. Menard discusses the characteristics of such semienclosed seas as the Andaman Sea, South China Sea, Sulu Sea, Celebes Sea, Banda Sea, Japan Sea, Okhotsk Sea, Gulf of Mexico, Caribbean, Mediterranean, Black Sea, and the southwest part of the Bering Sea.16 In contrast to the main ocean basins, the deep portions of these adjacent seas have a thick sedimentary section beneath their abyssal floors (figures 2A-B). According to Menard, the semienclosed seas amount to only 1 percent of the area occupied by the main deep-ocean basins, yet contain one-sixth the total volume of oceanic sediments.17 The structural and

stratigraphic nature of their sedimentary fill is just now being learned; the Gulf of Mexico is perhaps best known. Sediment thickness beneath the abyssal plain of the Gulf (Sigsbee Deep) has been estimated at about 7 km. 18 and may include sediments as old as early Mesozoic, probably Paleozoic. Numerous salt diapirs, the Sigsbee Knolls, have long been recognized within the abyssal plain; these diapirs are similar in many respects to producing domes along the Gulf Coast. 19

It is of interest to note that the JOIDES deep sea drilling project drilled a hole on one of these knolls in the Sigsbee Deep in a water depth of 11,720 feet (3,572 meters) which recovered oil in cores from depths of 450 to 472 feet (137 to 144 meters) in the cap rock of a salt dome.

The semienclosed seas need much further investigation to assess their potential, but at this state of knowledge, they should all be considered potentially prospective. Certainly, no seaward limit to potential within these basins could now be reliably drawn.

D. The Continental Margins

Geomorphic features of the ocean bottom associated with the continental margin include the continental shelf, the continental slope and the continental rise (figure 3A). There are many variations, however, in this "typical" profile. The shelf and slope cannot always be differentiated and not everywhere is there a continental rise. The shelf and slope form what has been called the continental terrace and are an integral part of continents. The nature and origin of this terrace have been discussed by many authors.²⁰

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- 12. B. C. Heezen, Personal communication,
- 13. Ewing and Ewing, (1964), op. cit., p. 535.
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Beyond the terrace is the continental rise which in its landward part commonly overlaps the submerged continental block. The continental rise has been compared to an alluvial fan, as it is comprised in large part of continental debris carried to the base of the slope by turbidity currents, gravity slides, submarine slumps, and bottom currents. These deposits accumulate as wedge-shaped masses that build seaward to distances of 100 to 1,000 km. from the lower slope (2,000-5,000 meters water depth) onto the abyssal plain and have estimated sediment thicknesses of as much as 10 km. or more. These submarine aprons are not everywhere present, but are particularly well developed off major river deltas (figure 3B) and constitute a substantial volume of the ocean sediments.21

In gross structure, continental margins vary considerably in detail; nevertheless, similarities appear to be greater than differences. "The crustal thicknesses of 20-30 km. of the continental or island platforms thin fairly abruptly to oceanic thicknesses in a distance of 100-150 km. Normally, the greatest part of this change starts 30-50 km. landward of the 1,000 fathom (or 1,829 meters) line and extends 30-50 km. seaward from it." 22 While not all continental margins have a thick sedimentary sequence above basement,23 many do have (figures 4-4M), and it is this thick sediment lens that makes the outer part of the continental margin attractive as a potential petroleum province. The sediment wedge beneath the shelf and slope (figure 1A) usually thins significantly, from several kilometers to 1 km. or less, across the area of crustal thinning. Along some continental margins there is a basement ridge (or ridges) near the outer edge of the continental shelf or upper "slope" (figures 4B-D) which apparently, as off California (figures 4I-J), traps large volumes of sediment just seaward of the continental shelf. Along the Atlantic slope, for example (figure 5), between the 100 fathom (183 meters) and 2,500 fathom (4,572 meters) lines, basement ridges separate several sediment-filled trenches 1.5 to 10 km. deep.

Menard and Smith have studied the areal extent of submarine provinces associated with the continental margin.²⁴ It can be deduced from their data that the combined areas of the slope and rise are comparable with or greater than that of the continental shelf. Sediment thicknesses beneath the slope and rise can be estimated in only a few areas from the limited seismic refraction data across the continental margin. Off the Grand Banks, for example, thicknesses are on the order of 20,000 to 30,000 feet; and similarly, off Browns Bank, Georges Bank, and Cape May. Thicknesses of 15,000 feet or more

have been estimated off Argentina, and some measurements have been made in a few other places. Sufficient data are not available, however, for reliable worldwide estimates of sediment volumes beneath shelves versus slopes and rises. Nevertheless, the data that are available suggest sediment volumes beneath rises and slopes will probably be substantially larger than those beneath shelves.

Worldwide exploration has already demonstrated the nature and potential of many continental shelves. Since the first major offshore discovery in 1947 (Block 32 Ship Shoal, 11 miles off Terrebonne Parish, Louisiana) continental shelf exploration has expanded to more than 75 countries, and production is now obtained offshore from 22 of these countries. As the next seaward province of exploration, the upper slope in several areas is already being considered. Examples include the northern Gulf of Mexico, the western Atlantic, and off California, where industry bid on a number of blocks between 600-1,500 feet (183-457 meters) water depths in the

^{21.} Menard and Smith, loc. cit.

^{22.} Worzel, op. cit., p. 346.

^{23.} Guilcher, op. cit., p. 299.

^{24.} Menard and Smith, loc. cit.

F. J. Gardner, "Offshore Oil Industry Big, Getting Bigger," Oil and Gas. Jour., April 22, 1968, pp. 133-38.

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Moore and Curray, loc. cit.
27. K. O. Emery, "Atlantic Continental Shelf and Slope of the United States," Geologic background, U.S. Geol. Survey Prof. Paper 529-A (1966), 23 pp.

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and C. S. Clay, "Continuous Seismic Profiles of the Continental Terrace Off Southeast Florida," Bull. Geol. Soc. Amer., vol. 77 (1966), pp. 31-44.

R. E. Sheridan et al., "Seismic-Refraction Study of Continental Margin East of Florida," Bull. Amer. Assoc, Petro. Geol., op. cit., pp. 1972-91.

E. Uchupi and K. O. Emery, "Structure of Continental Margin Off Atlantic Coast of United States," Bull, Amer. Assoc. Petro. Geol., vol. 51 (1967), pp. 223-34.

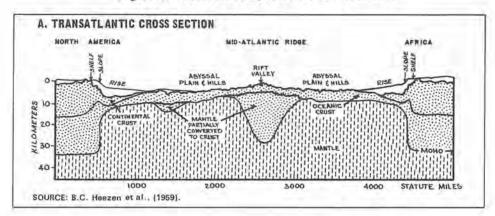
1968 Santa Barbara Channel lease/sale. The lower slope and continental rise are still relatively unknown, but several factors, including sediment thickness, and the high probability of good source potential, reservoir beds, and structural and stratigraphic traps, argue strongly in favor of their potential.

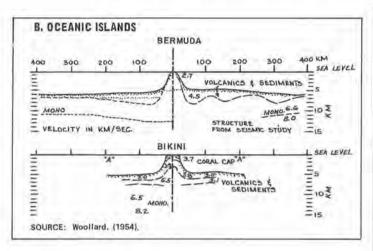
Seismic sections across the slope, such as those for the Atlantic,²⁸ Gulf of Mexico,²⁰ and West Coast ³⁰ indicate both structural and stratigraphic traps are present within the wedge of slope/rise deposits. That sands which could form reservoir beds get carried into very deepwater environments of the slope and rise has now been well documented (figures 6 & 9); the mechanism can be either gravity slide, bottom currents, or turbidity currents (figures 7, 8 & 10). Hydrocarbon potential of deepwater sediments, while

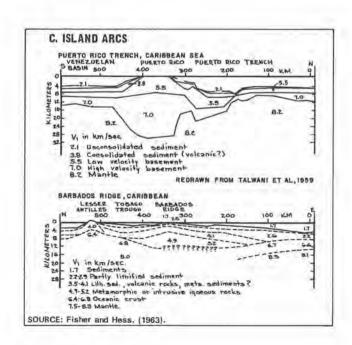
not yet evaluated, has been considered favorable in several studies.³¹ The continental rise environment has been cited as promising.³² The ingredients for potentially commercial accumulations of petroleum are, therefore, abundantly evident along the outer continental margin.

- 28. Uchupi and Emery, ibid.
- 29. Moore and Curray, loc. cit.
- J. R. Curray, "Structure of the Continental Margin Off Central California," Trans. New York Avad. Sci., vol. 27, Ser. 2, (1965), pp. 794-801.
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Figure 1. Ocean Basins, Islands, and Trenches







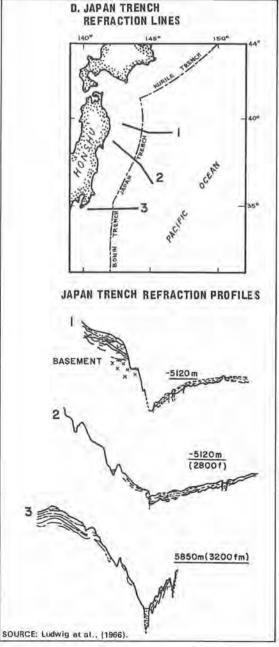
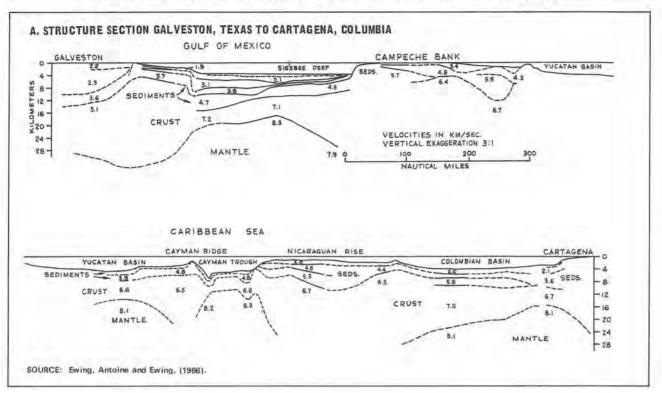


Figure 2. Gulf of Mexico, Caribbean, Western Mediterranean Structure Sections



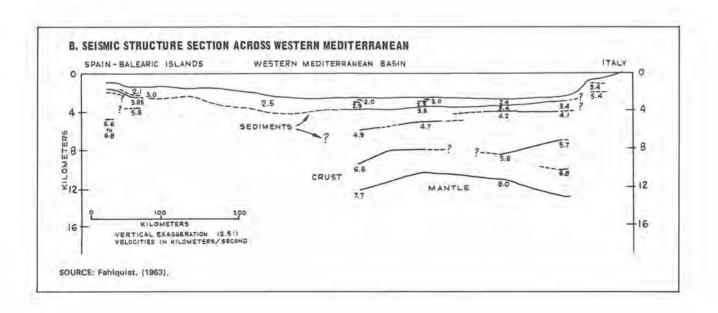
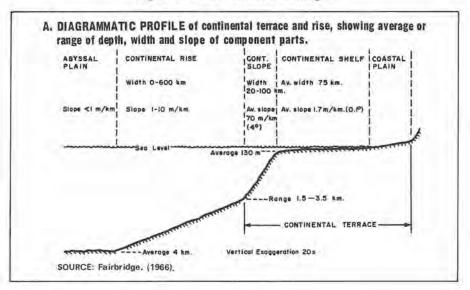


Figure 3. The Continental Margin



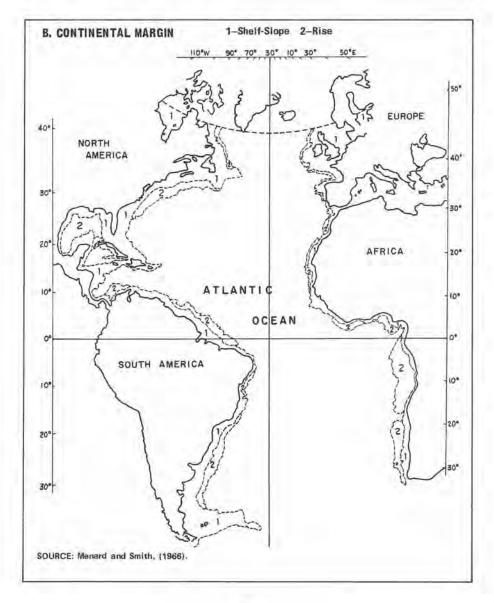
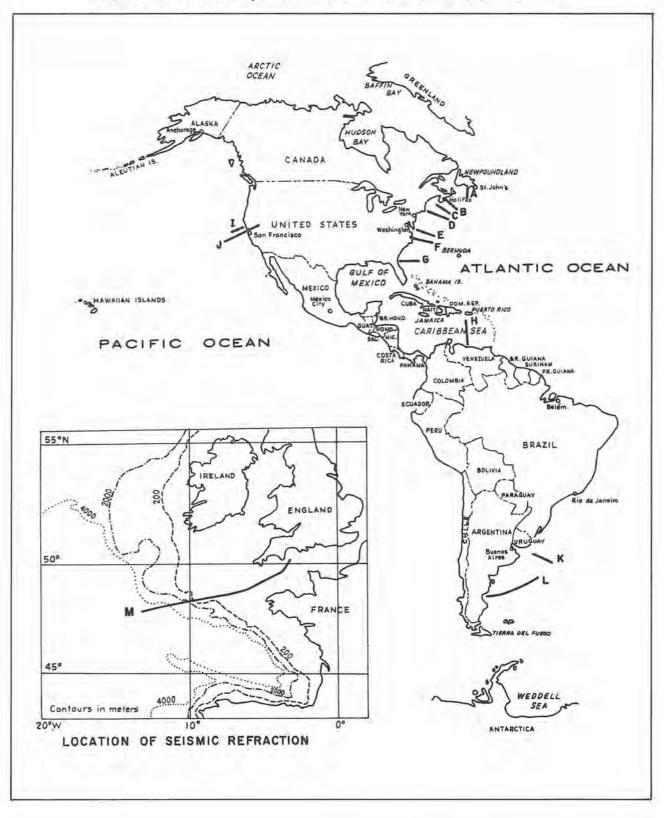
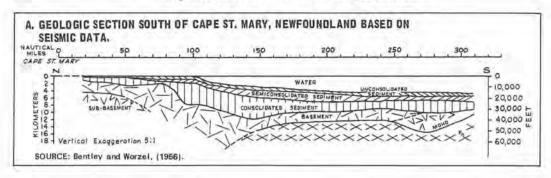
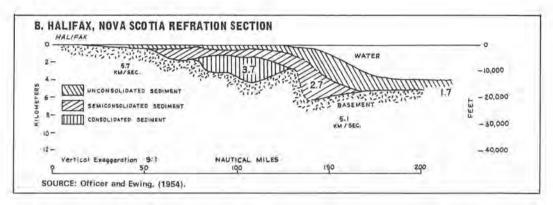


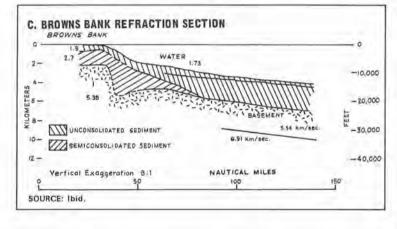
Figure 4. Locations of Representative Continental Margin Geophysical Profiles

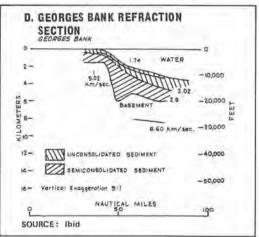


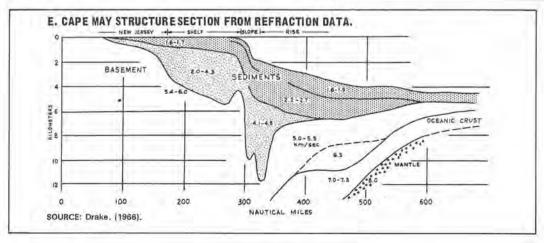
Figures 4A-4E. Continental Margin Profiles



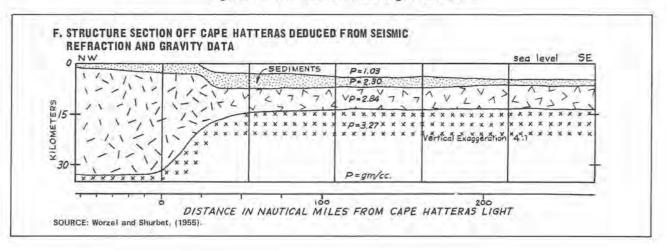


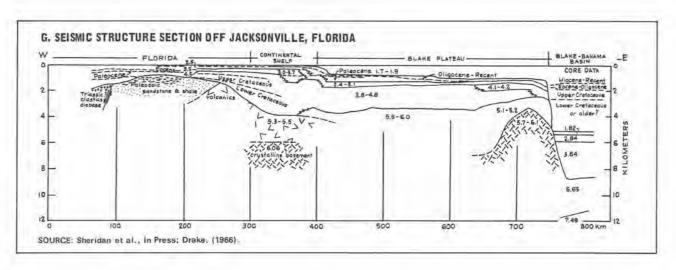


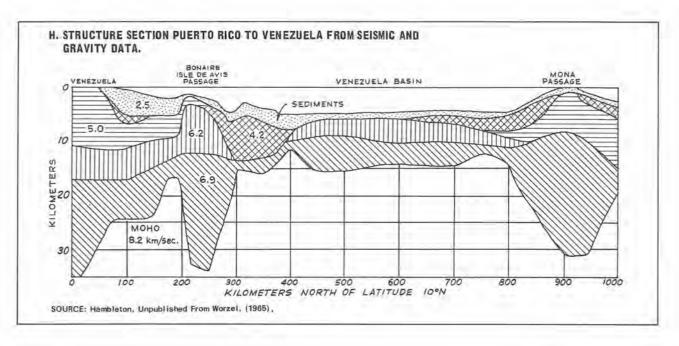




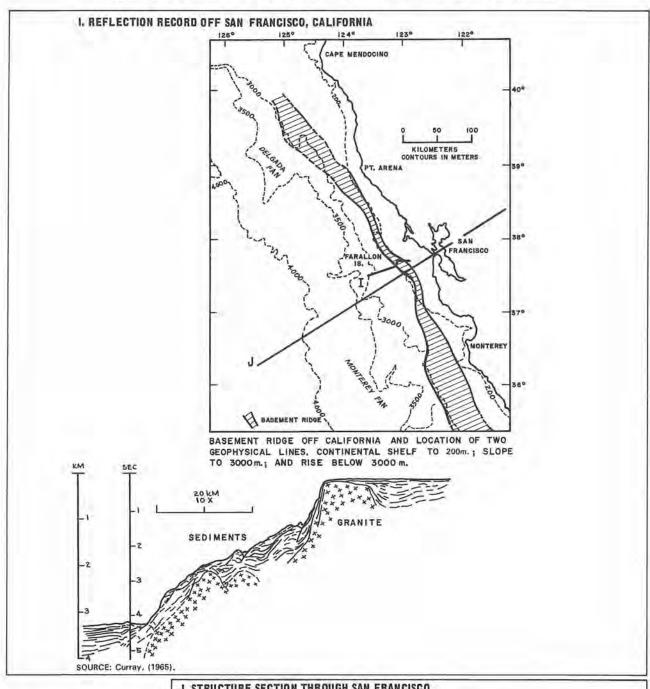
Figures 4F-4H. Continental Margin Profiles

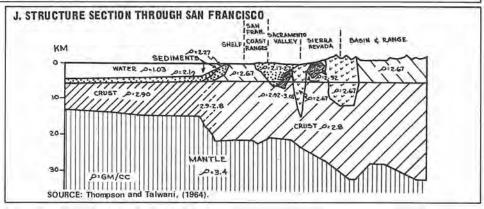




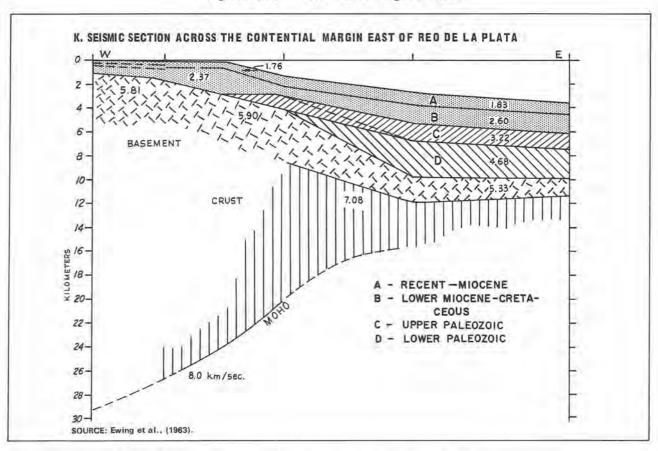


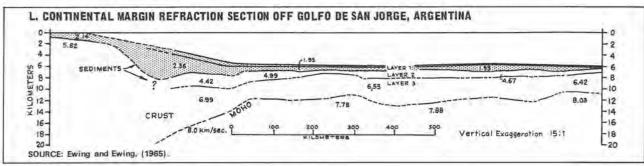
Figures 41-4J. Basement Ridge Off California and Continental Margin Profiles





Figures 4K-4M. Continental Margin Profiles





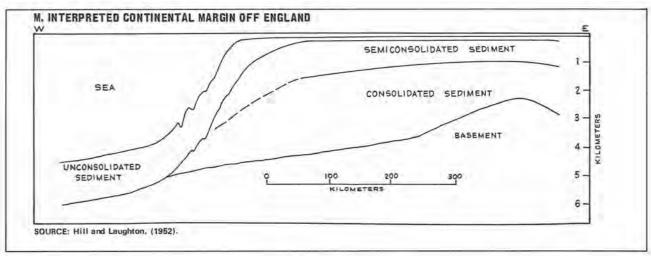


Figure 5. Continental Margin Trenches

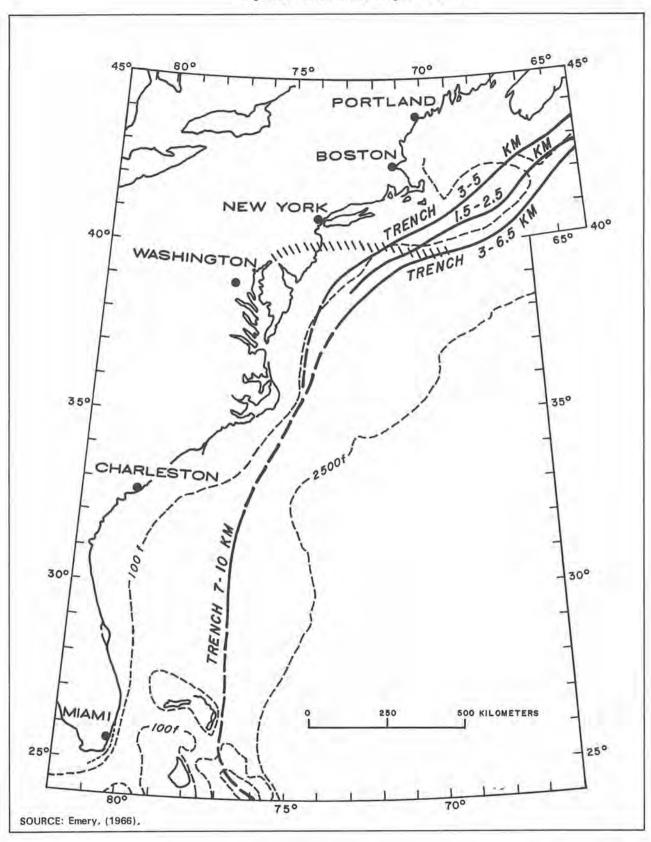


Figure 6. Distribution of Deep-Sea Sands in North Atlantic

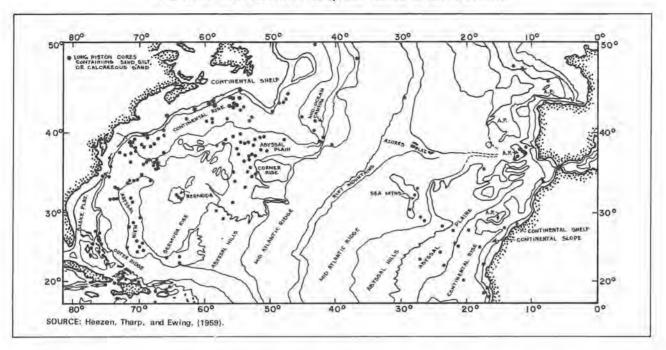


Figure 7. Distribution of Turbidites Within the Abyssal Plains of Northwest Atlantic

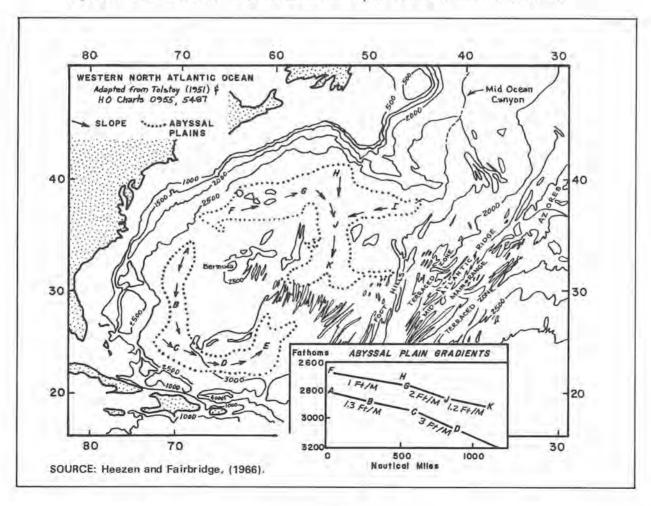


Figure 8. Turbidity Currents since 1880

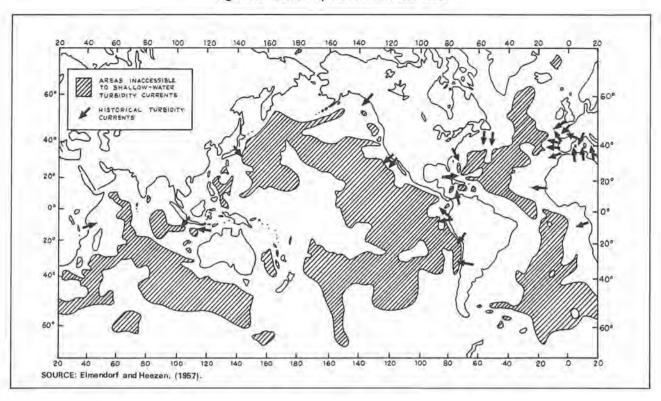


Figure 9. Cores Showing Sand Layers La Jolla Canyon and Fan

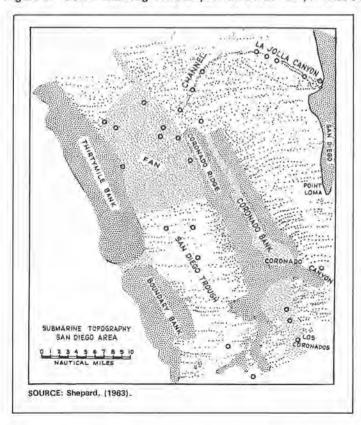
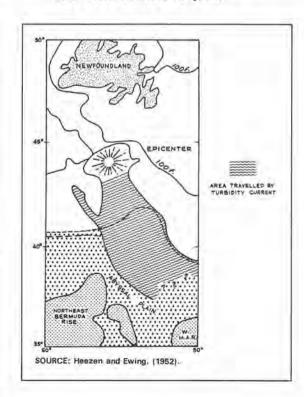


Figure 10. Turbidity Flow Caused by 1929 Grand Banks Earthquake



CHAPTER THREE—FIGURE REFERENCES

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CHAPTER FOUR—TECHNOLOGICAL CAPABILITY OF INDUSTRY FOR PETROLEUM DEVELOPMENT OF THE OFFSHORE AREAS

A. Introduction

Assuming a favorable political climate, the rate at which industry will move from near shore into progressively deeper waters in the exploration and exploitation of the natural resources of the continental margins will be governed primarily by three major factors. These are: (1) the potential for accumulation of commercial resources, (2) the technological capability to find and recover these resources, and (3) the economic attractiveness of the venture. Present knowledge of these factors diminishes with increasing water depths and distances from shore, and is very limited indeed with respect to the deep oceans. Estimates, particularly with reference to the time within which a given level of technical competence can be achieved, are not only important to industry and government for long-range planning, but are also of importance in determining the time interval available to achieve intelligent intergovernmental arrangements for the orderly development and exploitation of resources from the ocean depths beyond the national jurisdiction of the seabed and its subsoil.

None of the three basic factors enumerated above is completely independent of the others, because the rate of advancement of technological capability will depend upon the findings of deeper water exploration as to the actual presence of favorable accumulations of petroleum and the opportunity to exploit them profitably, given the technological capability. In estimating the development of technology for greater water depths, it has been assumed that sufficient incentive will prevail to promote its reasonable advancement.

Throughout the history of offshore petroleum operations, two principal motivating factors have influenced the development of offshore technology. One of these is the prospect of commercial production of petroleum in water depths or locations for which no technique or facility now exists. The other is the need to reduce capital and operating costs.

Innovations in technology in this area have been frequent and, when justified, the industry has been quick to apply them in its operations. When this is considered, along with the present status of offshore technology and the nature and extent of research and engineering now in progress, it is reasonable to expect that, if warranted by economic factors, a complete system for the exploration and exploitation of subsea resources lying beneath at least 1,500 feet (457 meters) of water will be achieved within 3 to 5 years, and that operational water depths may be extended from 4,000 to 6,000 feet (1,219 to 1,829 meters) within the next decade.

B. The Current Status of Offshore Petroleum Technology

1. Exploration and Drilling

In 1967, the NPC published a comprehensive report outlining technological developments in the petroleum industry from World War II through 1965. Chapter 5 of that study covers the evolution and status of technology in offshore operations. That report, along with a paper entitled "The Evolution of Offshore Mobile Drilling Units," generally reflect the current status of accepted and tested offshore technology for exploration and exploitation of petroleum deposits. The significant developments that have occurred since the publication of these documents which have influenced operational capability, or prediction of the rate of extending this capability offshore, are described below:

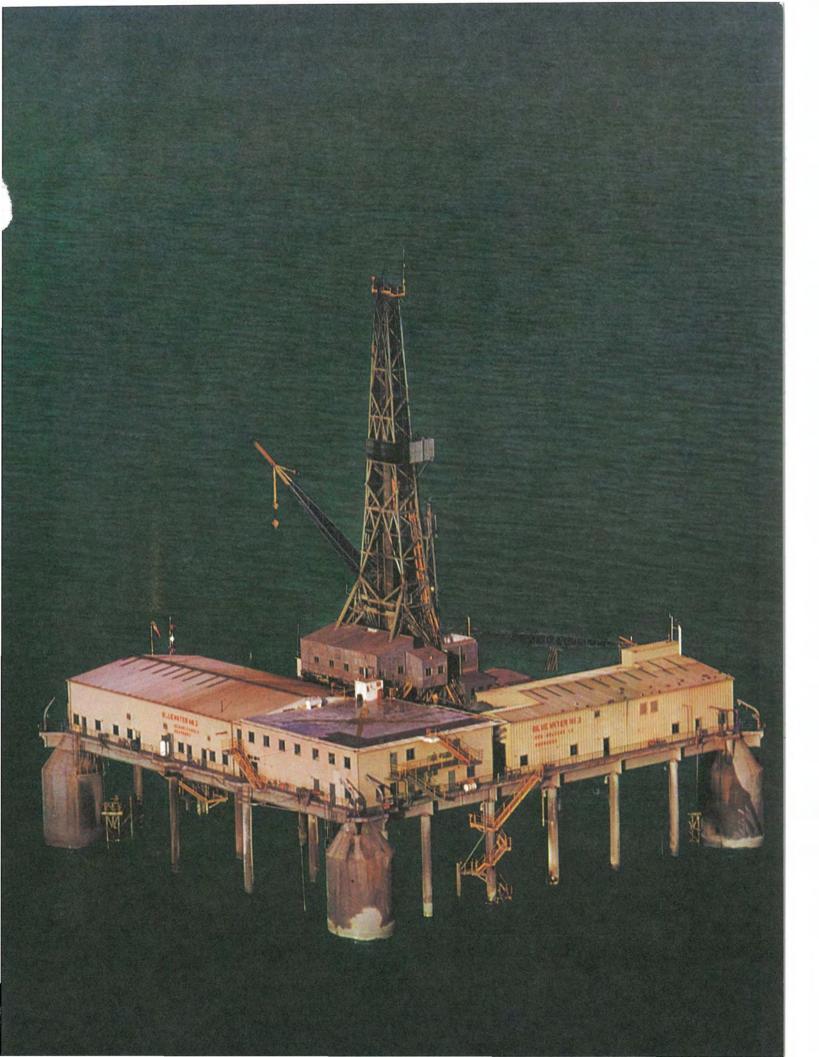
a) The status of offshore technology at the time of this study reflects a substantially

greater water-depth capability for exploration than for exploitation, which is limited more by production facility problems than by drilling technology. Considerable basic exploration research is being conducted in waters of the deep ocean, and geophysical surveys of various types can in general be carried out satisfactorily in deepocean water depths. Such exploration research is directly supported by many groups including universities, industry, government, and through international cooperation by the UNESCO Intergovernmental Oceanographic Commission activities and those of other interested international agencies. The current deep sea drilling project of JOIDES has further demonstrated that some degree of exploratory drilling can be conducted in the deep ocean even though no means for hole reentry have been available and penetration depths are limited by the life of a single bit. Thirtynine JOIDES holes had been drilled as of February 5, 1969, in the Gulf of Mexico and Atlantic Ocean. A maximum penetration of 2,738 feet (835 meters) into the ocean bottom was obtained at a location in 16,316 feet (4,973 meters) of water. Seventeen of these 39 holes were in water depths of 15,000-18,000 feet (4,572-5,486 meters). Such research drilling programs have been largely responsible for the experimental and developmental work on dynamic positioning (anchorless position-keeping) systems for surface and semisubmersible floating drilling devices. Dynamic postioning is now being utilized on a large mobile floating drilling device. Other surface floating drilling vessels are being contemplated for installation of anchorless position-keeping systems.

- b) Acoustical signal control of the subsea well-head and blowout preventers is being used in at least one exploratory drilling operation in the Santa Barbara Channel offshore area. If successful, this could eliminate some of the problems encountered with the present hydraulic-control system in greater water depths.
- A number of mobile drilling units now being designed or under construction are incor-

NPC, Impact of New Technology on the U.S. Petroleum Industry, (Washington, D.C., 1967).

Richard J. Howe, Drilling and Production Practice, (American Petroleum Institute, 1966).



porating modifications to accommodate greater mobility or towability. Some of these units are incorporating self-propulsion, and improvements in their below-waterline configuration should permit greater speed. The designed speed of these units ranges from 7 to 10 nautical miles per hour. Significant transportation cost reductions can be expected from such improvements in international operations when rigs are moved across the oceans of the world.

- d) Much work has been done to extend closed pressure system drilling capability to deeper waters to permit better control of drilling fluid and well behavior. Similarly, advances have been made in the technique of reentering wells with drilling tools by improving risers and mooring systems that allow drilling operations to be conducted in deeper water. The extent to which these improvements have been developed is indicated by their utilization in a well drilled in 1,300 feet (396 meters) of water in 1968.
- e) Of importance to both drilling and production operations are certain portions of underwater research conducted by the Navy, as well as petroleum industry operations in Alaskan waters and the North Sea. Successful application has been demonstrated of new high-strength steels having physical and chemical properties compatible with low-temperature water operations, and, in the case of the Navy's work, deepwater operations.
- f) Similarly, additional research on structural joint design, particularly that involving intersection of tubular members, has continued at various institutions. This effort should be beneficial to both mobile and fixed-platform construction.

2. Production

Commercial production operations, except in a few special situations, have to date been performed from above-water fixed platforms. These platforms have been installed in a maximum water depth of 340 feet (104 meters).

A few underwater wells have been completed and produced in water depths less than 300 feet (91 meters). In every case, however, the wells have been flowed to an above-surface production facility onshore or on a platform where oil and gas separa-

tion and related downstream production activities have been performed.

Recent developments pertaining to production include the following:

- a) Recently, several methods to operate remotely underwater wells and production facilities have been designed, developed and/or tested. The development of these could aid in accelerating the extension of exploitation capability beyond 600 feet (183 meters). Probably the most important roadblock in the application of such deepwater drilling and production systems is the testing and implementation of underwater and/or floating facilities for gathering and handling fluids.
- b) Improvements in fixed-platform design based upon better basic engineering data, as mentioned above, and experience gained with present platforms, have extended the water depths for which they can be employed economically. At present they are capable of being designed for depths as great as 600 feet (183 meters).
- e) Development of new designs for underwater storage, including one steel and concrete storage unit of 500,000-barrel capacity scheduled for installation in the Persian Gulf in 1969 in 130 feet (40 meters) of water at costs estimated to be comparable with floating storage.

Although, as will be noted in the next chapter, there exist some formidable economic barriers to extensive exploitation of resources in deep water, there will be some places where conditions appear sufficiently favorable to attempt exploitation in water depths greater than 600 feet (183 meters). In fields where the water is shallower than this depth and where prolific reserves of petroleum have been confirmed, the use of fixed above-water platforms for both development drilling and production is commercially achievable now. One such special case occurs in the Santa Barbara Channel off the coast of California. Here the Department of the Interior lease/sale of February 1968 resulted in the acquisition by producing oil companies of lease tracts in water depths up to 1,800 feet (549 meters). The unusual condition of 1,800-foot water depths lying so close to shore, in relatively sheltered waters, adjacent to a geological province for which there appears to be a high probability of large potential reserves, undoubtedly influenced the leasing of the tracts.

C. Prospects for New Technology

1. Drilling

It would appear that semisubmersible and surface floating mobile units will continue to be accepted as the best type of device for offshore exploratory and development drilling in deep water beyond the practical use of fixed above-water platform systems. Many problems related to such facilities remain to be solved and numerous opportunities for technological improvement exist. Mentioned previously is the need for relatively simple, reliable, and safe riser and reentry systems. Improved well fluid circulating and completion equipment, simple and foolproof subsea wellhead landing devices, and the like, are also needed. Recently, as already noted, attention has been directed to the improvement of the drilling vessel itself. Opportunity exists for improving the design of these vessels as to their motion characteristics, mobility, self-sufficiency, and their station-keeping ability.

2. Production

New techniques and facilities will be required to produce wells at depths beyond the limit of usefulness of fixed above-water platforms. The development and current testing of equipment, which offers the opportunity for remote control of the flow of wells under water, was mentioned earlier. There are many other operations for which provision must be made. These include pressure maintenance, artificial lifting, fluid and solid separation, paraffin and scale removal, well cleanout, storage and transportation of products, and other operations normally associated with well production.

Several approaches to the development of the required technology are being intensively pursued. These approaches can be divided into systems involving work with divers at current practical diving depths and those based on operations below current diving depths, or systems independent of divers. Many required functions would be far more readily accomplished if they could be done directly by man, and there is great incentive to develop his capability to work at increased water depths. A number of groups, including the Navy, have an interest in this development and much progress is being made. The use of new combinations and proportions of the components in the gas used for breathing and the development of saturation diving techniques have pushed the limit of water depth at which man can work effectively for prolonged periods down to 700 feet (213 meters) and depths as great as 1,000 feet

(305 meters) are contemplated. Nevertheless, there appear to be severe obstacles to achievement in the near future of greater practical working depths, and the use of divers, even in relatively shallow water, is costly.

Among the tools available to the systems designed to eliminate reliance on divers is the use of submersibles. Here again, a great deal of research and development is underway. Several submersibles have been used in underwater oilfield operations and a number of others are in various stages of development. Although the use of submersibles offers the potential to perform operations at virtually unlimited water depths, the vessels so far developed are very severely limited in their work capability and are very costly to use. Undoubtedly they will be much improved, and, as new technology is developed, they will find increasing application.

Still another approach which shows considerable promise is the use of large underwater chambers operating at subhydrostatic pressures in which well-heads and other production facilities can be enclosed and in which man himself can operate as required. These may or may not be made integral with storage facilities. Such chambers may be bottom-mounted or may be raised considerable distances above the seabed. Several of these have been developed through the design and engineering stage and one or more may be tested in the near future.

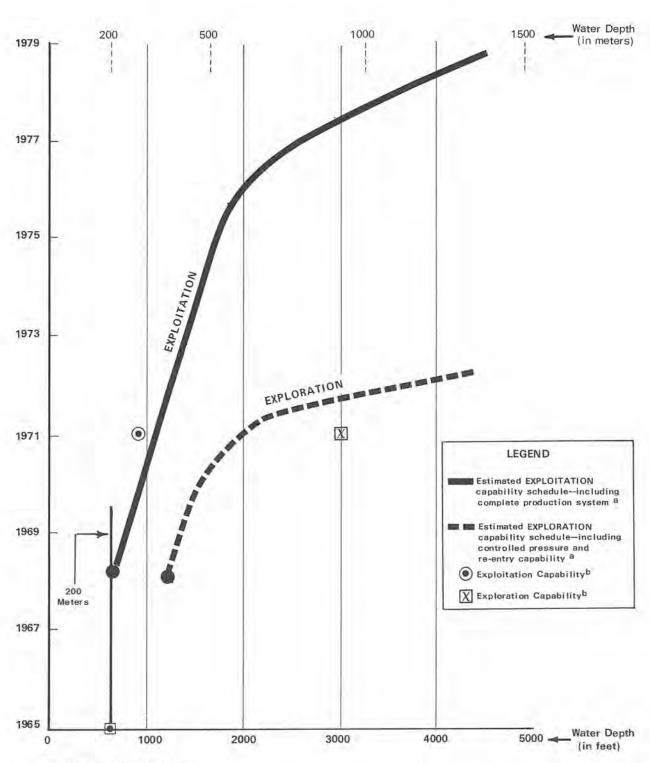
Feasibility of the new subsea systems is enhanced by the use of remotely controlled facilities installed directly upon or very near to the sea floor. Much effort is going into the design and engineering of such equipment and the means for controlling it.

D. Summary

There is no question that many new technological innovations will accrue from the effort currently being expended and it can be anticipated that the technology required for deepwater drilling and exploitation can be developed as required to meet the needs dictated by economics.

Best judgment estimates of the rate at which the industry will achieve the technological capability to proceed into even deeper waters, both to explore (with controlled pressure and reentry capability) and to exploit (with complete production system installation capability), appear in figure 11. It will be noted that the rate of exploration capability will considerably precede exploitation capability. Also, once exploration and exploitation capability is realized in depths of some 2,000 feet (610 meters) of water, it is anticipated that exploitation operations will become technically feasible at greater depths at a rate

Figure 11. Estimated Rate of Extending Exploration and Exploitation Capability Offshore



^a NPC Committee estimates

^b R. J. Howe, "The Evolution of Offshore Mobile Drilling Units," API Drilling & Production Yearbook (1966).

substantially higher than has been experienced throughout the offshore history to date.

In summary, industry already is able to carry out exploration drilling in waters as deep as 1,300 feet (396 meters) and it is estimated that the technological capacity for production at at least this depth could be realizable within 3 to 5 years. Beyond this depth range, the development of new technical concepts or systems now under consideration, or other

completely new technical developments, will be the controlling technological factor. It is reasonable to expect such developments to permit exploration and exploitation well beyond 1,300-foot depths within 10 years. Once these depths have been reached, progressive movement seaward on the submerged continent should be less sensitive to water depths and more sensitive to distances from shore.

CHAPTER FIVE—ECONOMICS OF OFFSHORE PETROLEUM EXPLORATION AND DEVELOPMENT

A. Introduction

The previous chapters of this report have stated that significant accumulations of petroleum exist beneath the continental shelf and may exist beneath the continental slope and rise. Moreover, the techniques and equipment needed to explore and develop these resources either exist now or can be feasibly developed in the future.

However, a basic and controlling consideration in the petroleum industry's decision to search for hydrocarbons in any area, whether onshore or offshore, is the ability to make a reasonable profit in the venture while continuing to furnish energy to the consumer at a fair price.

Petroleum now provides the largest share of the energy consumed in the United States and one significant reason is that it is competitive with, or better than, that of other domestic energy sources. Competition for the energy market will continue. Such sources as nuclear power, coal, and petroleum extracted from oil shale and coal, will maintain eco-

nomic limits on the price of oil and gas. It is within these economic limits that offshore petroleum resources will have to be developed.

Thus, a realistic appreciation and understanding of the economics of present offshore operations, and a prediction of the change of economic considerations with water depth, are essential to the formulation of any timetable for deep-ocean exploitation.

In this chapter emphasis is placed on the economics of the U.S. offshore oil industry, because more information is available about the domestic industry than about the economics of foreign operations. Furthermore, the major technical advances it offshore operations have been first applied in the United States. Also, the economics of crude oil production is stressed, with only passing attention given to production of natural gas, because present economics are more favorable for the deepwater production of oil, and because the trends described for crude oil are, in general, similar to those related to the production of natural gas.

B. Économics of Present Domestic Offshore Operations

I. Advancements of Domestic Offshore Industry

Figure 12 is a graphical presentation of the historical advancements of the domestic offshore industry, showing maximum water depth of acreage leased, exploratory wells drilled, and production established, as a function of time. This is *not* a series of curves of technical capability, but rather a series of curves which are determined by such factors as economic capability, opportunity, and exploratory success, as well as technical capability.

While leases were purchased in water depths of 100 feet (30 meters) in 1948, 300 feet (91 meters) in 1958, and 1,800 feet (549 meters) in 1968, the maximum water depth in which commercial production has been established to date is 340 feet (104 meters).

It appears that with greater water depths, the time lag increases between the time when leases are first purchased in a given water depth and the time when commercial production is first established from that depth.

Though the future may not necessarily follow the trends of the past, the economic capability to exploit offshore reserves in deeper waters can be generally expected to evolve quite slowly, until technology further evolves and the natural and economic environments become better known.

2. Lease Analysis

Under current offshore leasing practices, signifi-

cant bonus and other exploration expenses are incurred before the presence and size of hydrocarbon accumulations can be determined for a given prospect. The successful fields must be able to generate enough profit to pay for the expenses of the unsuccessful plays and to encourage industry to take the necessary risks. While it is difficult to take this into account in a field analysis, an investigation of specific lease/sales would incorporate some measure of the cost associated with unsuccessful and marginal ventures.

In 1967, J. W. Pittman analyzed the 1962 Federal Louisiana lease/sale and estimated a total payout for the \$1 billion industry investment of 12 to 15 years, as summarized in table 2.2 Considering that half of this investment was made at the lease/sale, and most of the remainder within 2 or 3 years, this long a payout period represents a low rate of return on investment (approximately 6 to 8 percent).3

Table 2—Summary of Results—1962 Louisiana Lease/Sale (as of July 6, 1967)

CAPITAL EXPENDITURES:	010	× 2000
Lease Bonus		Million
Wells	240	
Platforms	160	
Pipelines	90	
Facilities	20	
Rentals	45	
	1,000	Million
PRODUCING DRAINAGE POINTS:		
Oil 1iO	580	Oil Wells
Gas	10	Gas Wells
PRODUCTION:		
Oil & Cond.	7,300	B/D
Gas Sales		MMCF/D
ESTIMATED CURRENT ANNUAL		
CASH INCOME	70	Million
ESTIMATED CUMULATIVE		
CASH INCOME	100	Million
ESTIMATED TOTAL	904	
PAYOUT PERIOD	12 to	15 Years

Source: Pittman, (1967).

T. D. Barrow has presented a more detailed analysis of 1951 through 1965 discoveries for offshore Louisiana. His findings, as shown in table 3, indicate a 7 percent rate of return on the industry's \$6.3 billion investment.

 J. W. Pittman, "The Outlook for Domestic Drilling," Presented to Amer. Assoc. of Oilwell Drill. Contr., June 1967.

Return on investments given are based upon discounted cash flow method.

 T. D. Barrow, "Economics of Offshore Development." Presented at the Inst. on Explor. and Econ. of the Petro. Industry, March 1967.

The value of oil production per cubic foot of reservoir volume is greater than that of gas production. Also, oil usually can be stored and transported more easily than gas.

Figure 12. History of Domestic Offshore Activity

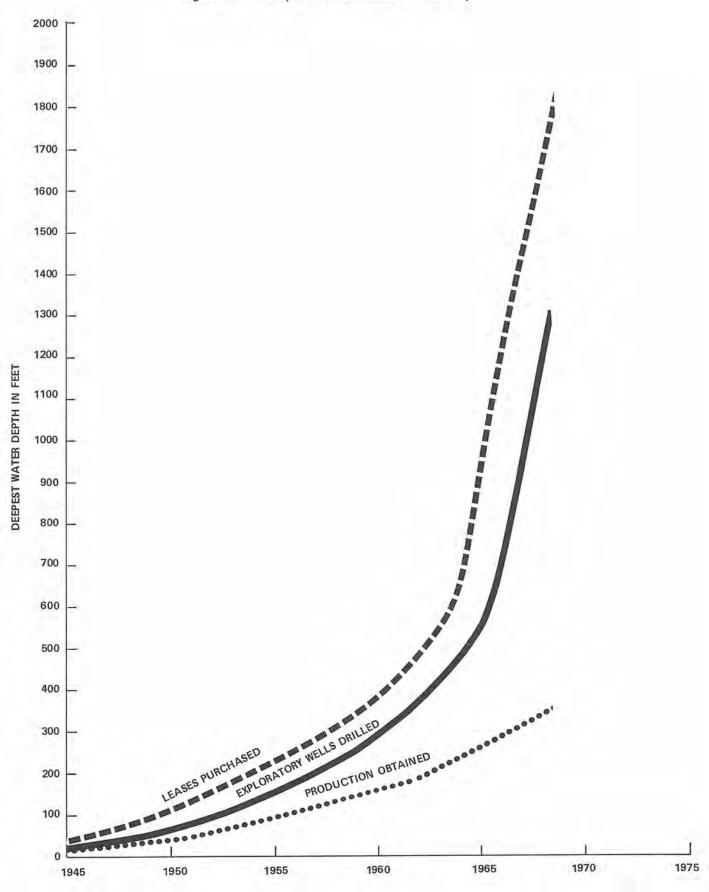
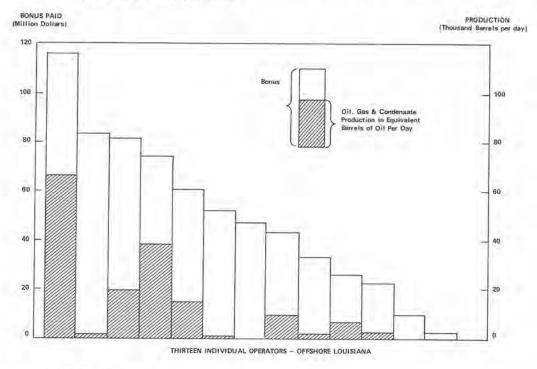


Figure 13. Bonus Paid for Offshore Louisiana Leases, By Thirteen Individual Companies (1954, 1955, 1960 and 1962 Lease/Sales) Compared with Mid-1966 Production from the Purchased Leases.



Source: T.D. Barrow, (1967).

Table 3—Exploration-Production Economics 1951 Through 1965 Discoveries Industry-Offshore Louisiana

Exploration Costs (Adjusted)	\$1,600	Million
Development Costs	4,700	Million
Total Investment		Million
Payout Status January 1, 1967	1,900	Million
Actual Value Profit	5,600	Million
Profit to Investment Ratio	0.9	
Investor's Interest Rate	7%	

Source: Barrow, (1967).

Barrow also points out that while the overall industry venture provides such a low rate of return, the results obtained by individual companies vary greatly. The magnitude of this variation is seen in figure 13, which is a plot of bonus payments by 13 individual companies as compared to mid-1966 production by these same companies from the acreage purchased.

Thus, if the offshore venture as analyzed by Barrow is to generate an acceptable return on invested capital, then leasing expenditures, royalties, or operating expenses will have to decrease, or the withdrawal rate or value of production will have to rise, or the economic environment will have to change in some other fashion. Of course, if the value of pro-

duction increases, other sources of hydrocarbons and nonhydrocarbon energy could become more competitive.⁵

Minimum Size Fields Being Produced in the Gulf of Mexico

It is also possible to think of the economics of offshore operations as they are reflected in the minimum size field which has been produced as a function of water depth. That is, costs increase significantly with water depth and distance from shore, and it is reasonable to assume that the smaller, more costly to produce fields will not be developed in deeper water.

Because a substantial time lag takes place between discovery and full evaluation of an offshore accumulation, there is a lack of data on development in wa-

American Oil Company, "Evaluation of 'Project H-Coal'." Prepared for Office of Coal Research, U.S. Dept. of the Interior, December 1967.

R. J. Cameron, "A Comparative Study of Oil Shale, Coal, Tar Sands as Sources of Oil." Presented at Sym. of Petro. Econ. and Eval., (SPE of AIME, March 1968).

E. H. Reichl, Liquefaction and Gasification of Coal. Presented at symposium "An Assessment of Some Factors Affecting the Availability of Oil and Gas in the United States Through 1980"; conducted by Office of Oil and Gas, U.S. Dept. of the Interior, March 1967.

ter depths greater than 100 feet (30 meters); however, it is apparent that, in general, only large, highly productive fields may be produced profitably in water depths greater than 400 feet (122 meters). Beyond the continental shelf, it appears that under present conditions, only even larger fields of high productive capacity may be produced profitably.

4. Overview of Present Economics.

The analyses described above present a reasonable picture of the economics of current offshore Louisiana operations. In summary, they indicate that costs rise rapidly with increasing water depth, and that in deeper waters of the continental shelf, costs on the average are already approaching marginal limits. Unless additional economic incentives appear to foster development of the offshore areas, the industry in the near future will most likely look to alternative nonconventional sources of petroleum. Moreover, as operations progress to deeper waters and farther from shore, only the larger, more productive accumulations of hydrocarbons will be economical to produce.

It must be remembered that the analysis of costs is based on the present economic environment of offshore Louisiana, by far the United States' most significant offshore producing province. While the trends described here will also apply to other areas, specific costs and capabilities may vary widely. In Cook Inlet, Alaska, for example, due to tides and ice floes, the cost of a platform in 100 feet (30 meters) of water is \$8-\$15 million compared to \$1-\$2 million in the Gulf of Mexico, and the cost of an 8-inch pipeline is \$60 per foot compared to \$10 per foot in the Gulf.⁶

In addition, in areas where well production is not prorated and where well productivity is higher than offshore Louisiana, the operator's rate of return on investment will be greater than indicated above, because of the time value of money.

C. Cost Projections for Deeper Water Operations

1. Cost Indices

The lack of cost data on production operations in water depths greater than 300 feet (91 meters) was discussed previously, as was the necessity of making assumptions and approximations to estimate the profitability of the existing offshore venture. There is no published forecast of the economics of operations in water depths greater than 400 feet (122 meters). However, it seems reasonable to extend the historic cost trends at least to 600 feet (183 meters) since it is felt that the current exploration drilling, plat-

form development and pipelining techniques will prove to be the most economical to at least this water depth,⁷ and thus there is no reason to expect a discontinuity in the trends.

It is also possible to obtain an indication of projected changes in total exploration and production costs with water depth by analysis of the effects of water depth on historical costs of exploration drilling, development drilling, production facilities, and pipelines. As shown in table 4, and explained in Appendix E, these components of the total exploration and development costs can be expected to be about twice as costly in 600 feet (183 meters) of water, and three to five times as costly in 1,000 feet (305 meters) of water, as they are in 100 feet (30 meters) of water.

Table 4—Variation of Major Components of Exploration and Development Cost with Water Depth

COST COMPONENT	COST MULTIPLYING FACTOR			
	12.0	SE CASE 00 FEET	600 FEET	1,000 FEET
Exploration Drilling a	8.8	1.0	1.5 - 2.0	2.0
Development Drilling	78	1.00	2.0 - 2.5 h	2.5 - 3.0°
Production Facilities		1.04	1.0 - 1.54	3.0 - 8.0 "
Pipelines t		1.0	1.0 - 2.0	2.0 - 3.0

ASSUMPTIONS (DETAILS IN APPENDIX E)

- a) Drilling is done from mobile or floating rigs.b) Utilizing and including the cost of fixed piling platforms.
- Drilled from floating rig and completed utilizing underwater wellhead. Also includes cost of flowline to a production facility.
- d) Cost of facilities required to process, measure and store crude oil on existing fixed piling platform.
- c) Cost of facilities and floating or underwater foundation required to process, measure and store crude oil.
- f) Cost per mile.

2. Model Field

An indication of the effect of these cost indices on the capital costs per barrel can be obtained by applying them to the model field developed by J. E. Wilson. From an analysis of this type it can be estimated that under existing conditions in the Gulf of Mexico the capital cost to produce crude oil is estimated to increase by more than 100 percent when moving from 100 to 600 feet of water, and by more

nomic and Social Council, February 1968.

M. E. Spaght, "The Development of Underwater Oil and Gas Reserves." Presented at Royal Swed. Acad. of Engrg. Sci., (1966).

J. R. Dozier, "Offshore Oil and Gas Operations, Present and Future." Presented at Law of the Sea Inst., Univ. of Rhode Island, June 1966.

[&]quot;Humble Gearing Up to Drill in 1300 Feet," Oil and Gas Journal, May 6, 1968.

[&]quot;Offshore Pipelining," Oil and Gas Journal, December 12, 1966. "Offshore Report," Oil and Gas Journal, July 10, 1967. Resources of the Sea, Report of the Secretary General, U.N. Eco-

J. E. Wilson, "Economics of Offshore Louisiana." Presented at Annual Mtg. of the Louisiana-Arkansas Div., Mid-Continent Oil and Gas Assoc., September 1967.

than 250 percent from 100 to 1,000 feet of water. In water depths well beyond the continental shelf it thus appears that a more economical supply of hydrocarbon energy may possibly be obtained from other conventional and nonconventional sources, rather than from offshore fields having a productivity per well similar to the average of those discovered to date in Louisiana.

3. Effects of Technological Innovations

A recent NPC study investigated the effects of improved technology on the cost of producing a barrel of oil.⁹ It was concluded that during the 15-year period 1950-1965, the following cost reductions were achieved:

TYPE EXPENSE	REDUCTIO ¢/B	REASONS
Drilling	35	Better rig equipment and analytical techniques for optimum drilling. Better drilling fluids.
Production	32	Artificial lift improvements and automation.
Corrosion Control	9	Better inhibitors and materials.
Well Spacing	100	Fewer wells needed due to im- proved reservoir study tech- niques.

These cost reductions, plus additional cost reductions due to more efficient management procedures, have been more than offset by inflation and the rising cost of construction. The value of a barrel of oil at the wellhead in 1950 was \$2.50 as compared to \$2.88 in 1965. However, during this time, the Engineering News-Record's construction cost index increased 98 percent and the Nelson refinery (inflation) construction cost index 86 percent, indicating that the cost of crude oil might have been expected to increase by more than \$2.00 per barrel. It is a tribute to the industry that technical and managerial innovations were able to permit profitable operations in spite of inflation, rising costs and stable crude prices.

New technology is a constantly evolving process, and as with all learning curves, the major cost reductions are made relatively early in the learning process. The industry as a whole has progressed relatively far along the curve during the past 100 years. Because of this, no major technological innovation is expected which will radically change the basic pro-

cedures by which oil is found and produced and thus drastically reduce costs.

Similarly, the chances for technological innovations which will significantly reduce the basic costs of offshore operations appear remote. The oil industry's oceanographic research effort has been in progress for over 15 years and has cost more than \$250 million. Therefore, although operations in deep water are just beginning, the industry should be well along on the offshore learning curve. Research is continuing, however, and several areas do exist where technological improvements are possible.

a) Floating Drill—Research on floating drilling techniques began in 1948 and several experimental underwater wells were drilling in the 1950's.¹² Hundreds of wells have been drilled from the 73 floating drilling vessels currently available ¹³ and the procedures are fairly well established. Therefore, costs should not be expected to drop dramatically in the near future.

There is a possibility for significant reductions in cost of the novel drilling techniques which will be required in very deep water beyond 1,500-2,000 feet (457-610 meters). However, costs of alternatives, such as onbottom drilling from habitats, are so prohibitively expensive at this time that technological innovations necessary to make them economically practical may well take several decades to evolve.

Dynamic positioning systems have been used since 1961.¹⁴ It is expected that technological innovations will enable the systems to overcome their primary technical problem of not being able to always provide rapid enough response to limit lateral movements of the drilling vessel, and these improvements may reduce costs somewhat. However, capital, operating, and maintenance costs will continue to be high, and it is expected that stationing costs will not be dramatically lowered in the near future.

b) Fixed Piling Platforms—The first offshore steel platform was erected in 1947 in 50 feet

NPC, Impact of New Technology on the U.S. Petroleum Industry 1946-1965, (1967).

Bureau of Mines, U.S. Dept. of the Interior, Minerals Yearbook, vol. II, (Washington, D.C.: Govt. Print. Ofc., 1948 thru 1966).

F. N. Ikard, "Offshore Petroleum Recovery, Status and Outlook," Under Sea Technology, January 1967.

^{12.} Spaght, loc. cit.

^{13.} Oil anl Gas Journal, April 22, 1968, pp. 158-182.

^{14.} Spaght, loc. cit.

(15 meters) of water off Louisiana. ¹⁵ Since that time more than 1,000 major fixed piling structures have been constructed in the Gulf of Mexico. ¹⁶

The industry has made sizeable investments in oceanographic studies to determine environmental design criteria, wave forces, pile design, tubular joint design, and material selection. While these studies have led to better design procedures and safer structures, rising construction costs have eliminated any cost savings. It is difficult to imagine that current research programs will significantly reduce platform costs in the near future.

c) Production Facilities—The steady technological advance of the oil industry has contributed to better-engineered production facilities (onshore and platform) which are capable of meeting the increasingly difficult task of separating solids, oil, water, and gas, while meeting stringent conservation criteria. It is expected that future technological innovations will follow this trend.

The area where innovations have the greatest potential for savings is in the design and operation of production facilities for water depth greater than 600 feet (183 meters). Significant innovations are necessary to make underwater or floating facilities economically attractive, but in view of the high cost of 600-foot platforms and the growing Federal expenditures on the "Man-In-The-Sea" program, it may be possible for underwater or floating facilities to be competitive with platforms in these depths. However, it must be emphasized that platform development in 600 feet of water has yet to be proven as an economic venture.

d) Pipelines—Offshore pipelines have been constructed since the earliest days of offshore production, and their progression into deep water

has generally followed production. The basic stinger, tensioning and "S-Curve" techniques are comparatively new and a 10 percent reduction in costs of using these techniques does not appear unreasonable. A major expense factor in offshore pipelining is welding cost and the speed at which welds can be made. It is expected that automatic welding machines, which are currently under development, will aid in reducing costs by an additional 10 to 20 percent. The novel methods which will have to be developed to install pipelines in more than 1,000 feet (305 meters) of water will cost more than present methods, and technological innovations may be able to reduce these costs to levels approaching current costs in 300 feet (91 meters) of water.

e) Summary—It does not appear that future technological innovations will drastically reduce the current and projected costs of offshore operations. Moreover, techniques for obtaining hydrocarbons from shale or coal are still in their infancy, and the industry is thus on the earliest, steepest part of the learning curve. Hence, advancing technology could well decrease the costs of the alternative sources of supply by a greater percentage than it will decrease the costs of deepwater operations.

However, because of the time required to overcome existing economic, technological, and legal problems involved in the utilization of alternate energy sources, it is doubtful that these sources will be important factors in the shortrange domestic supply picture. In the meantime, a large part of the domestic supply potential is in the offshore and the degree of dependence on imports may be largely determined by exploratory success in this environment.

15. Impact of New Technology, loc. cit.

Petroleum Production, Drilling & Leasing on the Outer Continental Shelf—A Summary, (U.S. Dept. of the Interior), May 1966.

CHAPTER SIX—CURRENT NATIONAL JURISDICTION OVER PETROLEUM RESOURCES OF OCEANIC AREAS

A. Introduction

The jurisdiction of the United States over the natural resources of the submerged areas off its coasts is determined by the Outer Continental Shelf Lands Act of August 7, 1953 (P.L. 212, 83rd Congress), and the 1958 Geneva Convention on the Continental Shelf. The Outer Continental Shelf Lands Act stipulates no precise geographic outer limit but instead prescribes simply that its terms shall govern mineral exploration and exploitation in the submerged lands lying beyond those of state ownership by the States of the Union ¹ and "of which the subsoil and seabed appertain to the United States and are subject to its jurisdiction and control."

The outer limit of U.S. jurisdiction is thus determined by the 1958 Geneva Convention on the Continental Shelf, as that is the treaty by which the subscribing nations, including the United States, have agreed on the rules to govern the exercise of sovereign

That is, the lands lying seaward of the limits of state ownership prescribed in the Submerged Lands Act of May 22, 1953.

rights by the coastal nations over the natural resources of the submarine areas adjacent to their coasts but outside the area of the territorial sea.²

Article 1 of the Convention provides that:

"For the purpose of these articles, the term 'continental shelf' is used as referring (a) to the sea-bed and subsoil of the submarine areas adjacent to the coast but outside the area of the territorial sea, to a depth of 200 metres or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas; (b) to the sea-bed and subsoil of similar submarine areas adjacent to the coasts of islands."

Article 2, in turn, prescribes that:

"1. The coastal State exercises over the continental shelf sovereign rights for the purpose of exploring it and exploiting its natural resources."

The result of these and other provisions of Article 2 is that:

- The jurisdiction of the coastal nation is limited to something less than full territorial sovereignty, being defined as "sovereign rights for the purpose of exploring it [the 'continental shelf'] and exploiting its natural resources"; but
- 2. The rights of the coastal nation are exclusive "in the sense that if the coastal State does not explore the continental shelf or exploit its natural resources, no one may undertake these activities, or make a claim to the continental shelf, without the express consent of the coastal State" (Article 2, par. 2); and, moreover,
- "The rights of the coastal State over the continental shelf do not depend upon occupation, effective or notional, or on any express proclamation." (Article 2, par. 3); and
- 4. The natural resources to which these exclusive sovereign rights relate consist of the "mineral and other non-living resources of the seabed and subsoil" together with sedentary living organisms (Article 2, par. 4).

Article 3 of the Convention stipulates that "The rights of the coastal State over the continental shelf do not affect the legal status of the superjacent waters as high seas, or that of the airspace above those waters." Articles 4 and 5 make a number of provisions for the protection of various specific rights of users of the high seas and the ocean floor beneath them.

For the purpose of determining the outer limit of coastal-nation jurisdiction, the definition of the "continental shelf" as set forth in Article 1 of the Convention is controlling. The key words in this definition, in turn, are:

- 1. "Submarine areas," i.e., not just the continental shelf in its strict geomorphic sense, but any submarine areas lying off the coast and otherwise meeting the requirements of Article 1;
- 2. "Adjacent to the coast," i.e., not to mid-ocean, but in sufficient proximity or appurtenance to the coast to qualify as "adjacent." Adjacency is, of course, a relative concept and what is proximate or appurtenant must be determined in the context of the vast expanses of the oceanic submarine areas of the world and not in a narrow sense; 3
- "To a depth of 200 metres," i.e., this far presently and unconditionally, without regard to the existence of a capability to exploit; 4
- 4. "Or beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas," i.e., as much farther beyond the 200 meters depth, within the outer limit of adjacency, as developing technology can be shown at any particular time to make such exploitation possible. In other words, this is not a static limit, conditioned upon exploitability as of a specific point in time, but is an elastic one, expanding with developments in technology.

It is thus apparent as noted in point 3 immediately above that the coastal nations have (a) a present and unconditional jurisdiction to the depth of 200 meters without regard to the existence of a capability to exploit, and (b) a further jurisdiction over the submarine areas specified in point 4 above whenever developing technology admits of the exploitation of said areas. Article 2, par. 2, of the Convention preserves the exclusive rights of the coastal nations

While there is widespread disagreement as to the breadth of the territorial sea, there is no disagreement as to the exclusive character of the jurisdiction and control of the coastal nation over the natural resources thereof, so that no special discussion of the territorial sea is required.

^{3.} The Truman Proclamation of September 28, 1945, entitled "Policy of the United States With Respect to Natural Resources of the Subsoil and Seabed of the Continental Shelf" (10 Fed. Reg. 12303), was the pioneer act of State in the development of the Continental Shelf Doctrine as a principle of international law. As will be shown at a later point (pp. 63-65), the concept of coastal-nation jurisdiction expanded considerably between 1945 and 1958, but the principle of appurtenance first enunciated in the Truman Proclamation remains the fundamental justification for the rights of coastal nations to the submarine resources off their coasts.

^{4.} The area within the 200-meter isobath is exempt from the exploitability test and automatically meets the adjacency test regardless of how far it extends from the coast. The history of the Convention clearly establishes that sovereign rights to the natural resources in this area out to 200 meters vested automatically and immediately in the coastal nation. In other words, the area out to the 200-meter isobath is conclusively presumed to be adjacent, subject to such questions as might arise concerning intervening deep depressions. See Dean, "Geneva Convention on the Continental Shelf," Tulane Law Review, vol. XLI, No. 2, pp. 419, et seq.

throughout whatever period of time is needed to permit the art of exploitation to achieve its ultimate depth capability within the limits of adjacency. As seems apparent, in light of technological advances to date, there will be an eventual capability to exploit any submarine area. Thus the test of adjacency alone determines the ultimate limit of national jurisdiction of coastal nations under Article 1 of the Convention and hence it is this test that fixes the boundary between national and international jurisdiction.

Accordingly, it is the outer limit of adjacency which will now be considered.

When the four key phrases, which have been analyzed above, are considered in light of the deliberations that led to their inclusion in the definition of the term "continental shelf" in Article 1 of the Convention, it can reasonably be concluded that the coastal nations' exclusive jurisdiction over the natural resources of the seabed and subsoil was intended to, and does, encompass in general, the continental mass seaward to where the submerged portion of that mass meets the abyssal ocean floor (including the continental shelf, continental borderland, continental slope, and at least the landward portion of the continental rise overlapping the slope).⁵

In addition, it is clear that in particular locales where the continent drops off abruptly from near the coastline to the abyssal ocean floor, it was intended that this exclusive jurisdiction should include an area of that floor "adjacent" to the continent.

This construction gives full weight to the explicit language of the Convention. It is in accord with the preparatory work of the International Law Commission (ILC) and the Conference which drafted the Convention; accords with the legislative history of the Convention in the U.S. Senate, and the representation of the State Department to the President and Senate in recommending ratification; is supported by the weight of legal opinion; is supported by the practice of states, including the U.S. Government, in the interpretation of the Convention and administration of submerged lands thereunder; and it corresponds to the factual problems and practical considerations which occasioned the treaty. These materials, to which recourse may properly be made in the interpretation of a treaty, are summarized below.

To mention one last special case, in semienclosed seas the surrounding coastal nations may well have a justifiable claim to natural resources jurisdiction to the median line, even where that line lies beyond the outer edge of a typical continental margin. Though the matter does not appear to have been discussed in the preparatory works leading to the choice of language employed in Article 1 of the Convention, the words actually used would appear broad enough

to sustain such a claim in the case of any semienclosed sea, such as the North Sea and the Gulf of Mexico, where the conditions of appurtenance or proximity are such as to meet the test of adjacency set forth in Article 1.

B. The Preparatory Work Leading to the Geneva Convention

The drafting of what eventually became the Geneva Convention on the Continental Shelf received the attention of the International Law Commission of the United Nations (hereinafter called the ILC) over a number of years, beginning with its first session in 1949.

In its first recommendation of specific language of a proposed treaty on the Continental Shelf at its third session in 1951, it recommended that coastalnation control and jurisdiction extend to the natural resources of a "continental shelf" defined as referring to:

"the sea-bed and subsoil of the submarine areas contiguous to the coast, but outside the area of territorial waters, where the depth of the superjacent waters admits of the exploitation of the natural resources of the sea-bed and subsoil." 6

At its fifth session in 1953, the ILC changed this language and defined the shelf solely in terms of water depths, using 200 meters as the outer limit, as follows:

"the sea-bed and subsoil of the submarine areas contiguous to the coast, but outside the area of the territorial sea, to a depth of two hundred metres." 7

This limitation proved entirely unacceptable, however, to the Organization of American States when representatives of 20 of its members met at the Inter-American Specialized Conference on "Conservation of Natural Resources: Continental Shelf and Marine Waters," held at Ciudad Trujillo (Dominican Republic) in March of 1956.

The representatives of these 20 states, including the representative of the United States with the con-

^{5.} See Glossary for explanation of these terms.

International Law Commission (ILC) Yearhook, vol. II, (1951), p. 141.

^{7.} ILC Yearbook, vol. II, (1953), p. 212. It may be noted that the motivation for this action was not the conclusion that the coastal states had no rights beyond the 200-meter depth, but rather that there was no urgency about provision for exploitation beyond that depth and that, in the meantime, it was desirable to minimize possible disputes between neighboring states by utilization of a formula capable of ready application. As stated in a subsequent report of the eighth session of the ILC: "The Commission was aware that future technical progress might make exploitation possible at a depth greater than 200 metres; in that case the limit would have to be revised, but meanwhile there was every advantage in having a stable limit." (ILC Yearbook, vol. II, [1956], p. 296). (Emphasis added.)

currence of the Department of State,8 unanimously adopted a resolution on March 28, 1956, reciting that:

"The sea-bed and subsoil of the continental shelf, continental and insular terrace, or other submarine areas, adjacent to the coastal state, outside the area of the territorial sea, and to a depth of 200 meters or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the sea-bed and subsoil, appertain exclusively to that state and are subject to its jurisdiction and control." (Emphasis added.)

The report of the discussions leading to this conclusion stated, inter alia, that:

"(m) Scientifically, the term 'continental shelf' is understood to be that portion of the continent or island which is covered by the waters up to the point of declivity of the slope or edge of the shelf. . . .

"(o) Scientifically, the term 'continental slope', or inclination, refers to the slope from the edge of the shelf to the greatest depths. (Emphasis added.)

"(p) 'Confinental terrace' is understood to be that part of the submerged land mass that forms the shelf and the slope." 9

The report went on to say that "from the study of the above-mentioned points, the following conclusions may be drawn:

"I. The American states are especially interested in utilizing and conserving the existing natural resources on the American terrace (shelf and slope).

"II. As the edge of the continental shelf varies in depth, it is advisable to describe it conventionally as the submerged part of the continents or islands to depths of 200 meters (100 fathoms, more or less).

"III. The utilization of the resources of the shelf cannot be technically limited, and for this reason the exploitation of the continental terrace should be included as a possibility in the declaration of rights of the American states. . . ." 10

The only conclusion to be drawn from these remarks, and particularly from the reference to the continental terrace as encompassing the slope "from edge of the shelf to the greatest depths," is that the conferees at Ciudad Trujillo intended, inter alia, to assert the national jurisdiction of the American states over the entire submerged portion of the continental mass of the American continents.

It is necessarily a matter of speculation as to how the conferees at Ciudad Trujillo would have treated the American "continental rises" had that term been in common use at the time of the Conference. It seems entirely clear, however, that under any circumstance their claim of national jurisdiction "to the greatest depths" was broad enough to include at least those landward portions of the continental rises that are clearly identifiable with the submerged portion of the continental mass. Accordingly, the right of the United States to assert national jurisdiction to that extent is fully supported by the inter-American conclusions at Ciudad Trujillo.

The ILC convened for its eighth session only a few weeks after the close of the Ciudad Trujillo Conference and prepared final recommendations on the text of its proposed convention on the continental shelf. Dr. F. V. García-Amador of Cuba, who had represented his country at Ciudad Trujillo, was elected chairman of the session and, at the very outset of the discussion, he recommended amendments to the 1953 ILC draft to bring it in line with the conclusions reached at the Ciudad Trujillo Conference, including specific reference to the continental terrace as being included within the jurisdiction of the coastal nations for the purposes of the treaty.¹¹

Subsequently, while adhering to his insistence on language permitting the exploitation of adjacent areas beyond the depth of 200 meters, whether or not they formed a part of the geological continental shelf, he dropped his request for specific reference to the continental terrace for reasons explained as follows in the official report of the session: 12

"6. He did not wish to press the part of his amendment introducing the concept of the continental terrace, since the adoption of the second point relating to the depth at which exploitation was practical would automatically bring that area within the general concept. He would, however, request the Commission to take a decision on the right of States to exploit the natural resources of the sea-bed in adjacent waters to whatever depth was practicable. With that addition, the article could be referred to the Drafting Committee." 13 (Emphasis added.)

The debate was subsequently summed up by one of the other members of the ILC, Mr. L. Padilla-Nervo of Mexico, to the effect that what in fact the Commission had to vote on was the Chairman's proposal to incorporate in Article 1 the concept contained in the words "or, beyond that limit, to where the depth of the superjacent waters admits of the

Digest of International Law, vol. 4, (Department of State, 1965), Publication 7825, p. 837.

 [&]quot;Final Act, Inter-American Specialized Conference on Conservation of Natural Resources: The Continental Shelf and Marine Waters," (Ciudad Trujillo, March 15-28, 1956), pp. 32-34.

Ibid., p. 34.
 ILC Yearbook, vol. I. (1956), pp. 130-31.

^{12. 1}bid., p. 136.

^{13.} M. S. McDougal and Wm. T. Burke comment on this development as follows in their work on The Public Order of the Oceans, p. 683: "Some controversy attended the suggested elimination of the continental shelf term and the references to the 'continental and insular terrace', but this became muted when it was realized that a criterion embracing both a 200-meter depth and the depth admitting exploitation would embrace such areas if they were in fact exploitable or came to be."

exploitation of the natural resources of the said areas." The question was then put to a vote and the proposed addition to Article 1 was adopted by the Commission.14

With this addition and a few other changes made in the language of the ILC 1953 draft, which are not here pertinent, the language finally recommended to the General Assembly of the United Nations was as follows:

ARTICLE 67

"For the purposes of these articles, the term 'continental shelf' is used as referring to the seabed and subsoil of the submarine areas adjacent to the coast but outside the area of the territorial sea, to a depth of 200 metres (approximately 100 fathoms), or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas." 15

The result of the deliberations of the ILC on the wording of this article is effectively summarized as follows in its official report to the U.N. General Assembly:

"(4) At its eighth session, the Commission reconsidered this provision. It noted that the Inter-American Specialized Conference on 'Conservation of Natural Resources: Continental Shelf and Oceanic Waters', held at Ciudad Trujillo (Dominican Republic) in March 1956, had arrived at the conclusion that the right of the coastal State should be extended beyond the limit of 200 metres, 'to where the depth of the superjacent waters admits of the exploitation of the natural resources of the seabed and subsoil'. Certain members thought that the article adopted in 1953 should be modified. While agreeing that in present circumstances the limit adopted is in keeping with practical needs, they disapproved of a provision prohibiting exploitation of the continental shelf at a depth greater than 200 metres even if such exploitation was a practical possibility. They thought that in the latter case, the right to exploit should not be made subject to prior alteration of the limit adopted. While maintaining the limit of 200 metres in this article as the normal limit corresponding to present needs, they wished to recognize forthwith the right to exceed that limit if exploitation of the seabed or subsoil at a depth greater than 200 metres proved technically possible. It was therefore proposed that the following words should be added to the article, 'or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas'. In the opinion of certain members this addition would also have the advantage of not encouraging the belief that up to

200 metres depth there is a fixed zone where rights of sovereignty other than those stated in article 68 below can be exercised. Other members contested the usefulness of the addition, which in their opinion unjustifiably and dangerously impaired the stability of the limit adopted. The majority of the Commission nevertheless decided in favour of the addition. (Emphasis added.)

"(5) The sense in which the term 'continental shelf' is used departs to some extent from the geological concept of the term. The varied use of the term by scientists is in itself an obstacle to the adoption of the geological concept as a basis for

legal regulation of this problem. . . .

"(9) Noting that it was departing from the strictly geological concept of the term, inter alia, in view of the inclusion of exploitable areas beyond the depth of 200 metres, the Commission considered the possibility of adopting a term other than 'continental shelf'. It considered whether it would not be better, in conformity with the usage employed in certain scientific works and also in some national laws and international instruments, to call these regions 'submarine areas'. The majority of the Commission decided to retain the term 'continental shelf' because it is in current use and because the term 'submarine areas' used without further explanation would not give a sufficient indication of the nature of the areas in question. The Commission considered that some departure from the geological meaning of the term 'continental shelf' was justified. provided that the meaning of the term for the purpose of these articles was clearly defined. It has stated this meaning of the term in the present article." 16 (Emphasis added.)

When the U.N. Conference on the Law of the Sea convened in Geneva in February of 1958 for the purpose of reducing to formal treaties the various recommendations of the ILC on the law of the sea, it was the language of Article 67 of the 1956 ILC draft that was submitted to the Fourth Committee (Continental Shelf) for consideration. It was also this very language, unchanged except for the elimination of the imprecise parenthetical reference to 100 fathoms as the equivalent of 200 meters and the addition of language to make the Convention specifically applicable to submarine areas adjacent to the coasts of islands, that was carried into the final, official text of Article 1 of the Geneva Convention on the Continental Shelf as signed and/or ratified by the United States and 38 other nations.

16. Ibid., pp. 296-97.

^{14.} ILC Yearhook, op. cit., 139-40.

^{15.} ILC Yearbook, vol. II, (1956), p. 296.

Accordingly, it is clear that Miss Marjorie M. Whiteman, a member of the U.S. delegation at Geneva in 1958, and an adviser to the U.S. representive at Ciudad Trujillo in 1956, was expressing the general understanding of the Conferees at Geneva as well as the official views of the U.S. Government as to what the Geneva Convention was intended to accomplish when she stated that:

"The definition of the rights of the coastal State to the continental shelf and continental slope adjacent to the mainland proposed by the International Law Commission would benefit individual States and the whole of mankind." 17 (Emphasis added.)

One of the last official acts at Geneva prior to the signatures to the Convention on the Continental Shelf was a plenary session vote on whether the jurisdiction of the coastal nations should be couched in the broad terms recommended by the ILC at its eighth session in 1956 and approved by the Fourth Committee at Geneva, or should be cut back to the 200-meter isobath as proposed at the earlier fifth session of the ILC in 1953. This vote was heavily in favor of the broad definition.¹⁸

Let us now consider the principle of equality incorporated into Article 1 of the Convention to take care of those situations where the submerged portion of the continent is narrow and its edge drops off abruptly to the abyssal ocean deep.

In addition to the insistence at Ciudad Trujillo and subsequently by the ILC and the Geneva Conference on the Law of the Sea on recognition of the jurisdiction of the coastal nations over the mineral resources of the entire submerged portion of their continental land mass, it was brought out in the discussions by all three groups that under principles of equality recognition also had to be given to the rights of coastal nations in those situations where the continent drops off abruptly from near the present coastline to the abyssal ocean floor. In the Ciudad Trujillo Resolution, in which the term "continental shelf" was used in its technical, geomorphic meaning, this was accomplished by extending coastal-nation jurisdiction and control not only to the continental shelf and the continental and insular terrace, but also to "other submarine areas, adjacent to the coastal state." In the ILC final 1956 draft and in Article 1 of the Geneva Convention, in both of which coastalnation jurisdiction and control were extended to the natural resources of the "continental shelf," this was accomplished by getting away from the technical meaning of the term and defining "continental shelf" for the purposes of the Convention generically as "the seabed and subsoil of the submarine areas adjacent to the coast, etc." (Emphasis added.)

In its final 1956 report on the proposed conven-

tion, the ILC expanded on its previously discussed reasons for departing from strict technical concepts, stating that:

"(6) There was yet another reason why the Commission decided not to adhere strictly to the geological concept of the continental shelf. The mere fact that the existence of a continental shelf in the geological sense might be questioned in regard to submarine areas where the depth of the sea would nevertheless permit of exploitation of the subsoil in the same way as if there were a continental shelf, could not justify the application of a discriminatory legal regime to these regions.

"(7) While adopting, to a certain extent, the geographical test for the 'continental shelf' as the basis of the juridical definition of the term, the Commission therefore in no way holds that the existence of a continental shelf, in the geographical sense as generally understood, is essential for the exercise of the rights of the coastal State as defined in these articles. Thus, if, as is the case in the Persian Gulf, the submarine areas never reach the depth of 200 metres, that fact is irrelevant for the purposes of the present article. Again, exploitation of a submarine area at a depth exceeding 200 metres is not contrary to the present rules, merely because the area is not a continental shelf in the geological sense." ¹⁹ (Emphasis added.)

As the pertinent language of the 1956 ILC draft was incorporated without change in Article 1 of the Geneva Convention, these observations, of course, equally apply to the language of that article. Dr. García-Amador, the representative of Cuba at the Ciudad Trujillo Conference who, as previously noted, subsequently served as chairman of the ILC during its eighth session and who also headed his country's delegation at the Geneva Conference, has commented on this point as follows:

"As we have indicated, the geographical configuration of the bed of the sea contiguous to the coast of continents and islands is sometimes so irregular that it cannot be defined in terms of the shelf or terrace concepts. When this is so, as in the case of some countries in the American continent and elsewhere, the coastal State may exercise the same exclusive rights now enjoyed by those which have a continental or insular shelf and terrace, provided the depth of the superjacent waters admits of the ex-

Summary Records of Meetings of Fourth Committee, U.N. Document A/Conf. 13/42, p. 40.

^{18.} Forty-eight votes to twenty, with two abstentions; U.N. Document A/Conf. 13/38, p. 13. Interestingly enough, even though many of those now seeking the broadest possible international regime have advanced the needs of the developing countries as one of their main reasons for such a regime, the developing nations represented at Geneva were virtually unanimous in supporting the retention of a broad definition of national jurisdiction.

^{19.} ILC Yearbook, op. cit., p. 297.

ploitation of the natural resources of the seabed and subsoil and that the submarine area be adjacent to the territory of the coastal State. (Emphasis added.)

"... States enjoy present legal powers when the submarine area adjacent to their territory has the configuration of a shelf, defined by the limit of the 100-fathom line. Potential or future powers would be enjoyed by them, for example, according to the system adopted by the International Law Commission, with respect to the slope and the corresponding part of the terrace, and by all coastal States with regard to the other submarine areas adjacent to their territories..." ²⁰ (Emphasis added.)

C. Construction of the Treaty at the Time of Ratification by the United States in 1960

The Honorable Arthur H. Dean was the chairman of the U.S. delegation at the U.N. Conference on the Law of the Sea held in Geneva in 1958. It was this conference that produced, *inter alia*, the Geneva Convention on the Continental Shelf and it was Ambassador Dean who served as spokesman for the Department of State in the ratification hearings before the Senate Foreign Relations Committee on January 20, 1960. The pertinent portion of his prepared statement is as follows:

"The Convention on the Continental Shelf gives international recognition to a legal concept first promulgated by the United States.

"President Truman's Proclamation of 1945 and the Outer Continental Shelf Lands Act passed by Congress in 1953 (67 Stat. 462, title 43 U.S.C.A. sections 1331 et seq.), were motivated by the need to protect the petroleum deposits beneath the high seas beyond the territorial sea around our coasts, which newly invented techniques opened for extraction for the first time. A number of other nations have since put forward similar claims to their continental shelves.

"The term 'Continental Shelf' is defined in article 1 (a) to include:

"'... the seabed and subsoil of the submarine areas adjacent to the coast but outside the area of the territorial sea, to a depth of 200 meters (655 feet) or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas.'

"Article 1 (b) makes clear that the concept of the Continental Shelf applies to 'the seabed and subsoil of similar submarine areas adjacent to the coasts of islands.'

"Thus, the Continental Shelf is presumed to be exploitable at a depth of 200 meters beneath the surface of the sea, and may be exploited beyond that depth where technological developments can be shown to make such exploitation possible.

"The clause which protects the right to utilize advances in technology at greater depths beneath the oceans was supported by the United States and was in keeping with the inter-American conclusions at Ciudad Trujillo in 1956. It was included in the ILC 1956 draft." ²¹ (Emphasis added.)

This representation of the State Department to the Senate accords with the State Department's explanation of the Convention to the President. The letter of Acting Secretary of State Dillon transmitting the Convention to President Eisenhower September 2, 1959, stated that the Convention "combines both the depth and exploitability tests as did the International Law Commission's draft." 22

The State Department did not suggest to the Senate or the President the possibility of any different interpretation of the Convention. Therefore, the NPC feels that when the Senate gave its advice and consent to ratification of the Convention on the Continental Shelf in light of these statements, and the President ratified the Convention, the Executive Branch was committed to a position on the jurisdiction of the United States over the natural resources lying off U.S. shores in keeping with the inter-American conclusions at Ciudad Trujillo in 1956 and the ILC 1956 draft. That position recognized exclusive jurisdiction in the coastal state with respect to the resources of the seabed of the continental shelf and "slope from the edge of the shelf to the greatest depths." This is a part of the American mineral estate, now vested in the United States. It is this position that the National Petroleum Council continues to support today.

D. Prevailing Legal Opinion

There are those who ignore the test of adjacency specifically written into Article 1 of the Convention on the Continental Shelf and implicit in all the discussions that led to the drafting of that article. They would apply exploitability as the only test, leaving the median line provisions of Article 6 of the Convention as the only limit to national jurisdiction, even if that extends national jurisdiction to midocean. On the other extreme are those who give scant attention to the exploitability test and read the Convention as though it limited national jurisdiction to the 200-meter isobath. Both of these views are re-

Garcia-Amador, The Exploitation and Conservation of the Resources of the Sea, 2nd ed. (1959), pp. 108 and 130.

See Hearings before the Committee on Foreign Relations of the U.S. Senate on Conventions on the Law of the Sea. 86th Cong. 2nd sess. January 20, 1960, pp. 108-09.

^{22.} Digest of International Law, op. cit., p. 829.

jected in favor of the one advanced in this report which gives full weight to both the adjacency and the exploitability tests, and to the deliberations at Ciudad Trujillo and within the ILC, and subsequently at Geneva which led to their adoption in the final text of the Convention.

The matter is succinctly stated in a joint report to the 1968 session of the House of Delegates of the American Bar Association (ABA) by the Section of Natural Resources Law, the Section of International and Comparative Law, and the Standing Committee on Peace and Law Through United Nations of that Association. This report states that:

"The Convention's definition of the seaward extent of the coastal state's jurisdiction has been subjected to a number of interpretations.

"Some argue that the factor of exploitability would carry the coastal nation's exclusive mineral jurisdiction to mid-ocean. We disagree. Others argue that it should be restricted to waters as shallow as 200 meters or 12 miles from shore. We disagree with this, too.

"The better view, in our opinion, is that the 'exploitability' factor of the Convention is limited by the element of 'adjacency'. The exclusive sovereign rights of the coastal nations to the exploration and exploitation of the natural resources of the seabed and subsoil encompass 'the submarine areas adjacent to the coast but outside the area of the territorial sea.' According to this view, therefore, the exclusive sovereign rights of the coastal nations with respect to the seabed minerals now embrace the submerged land mass of the adjacent continent down to its junction with the deep ocean floor, irrespective of depth." ²³ (Emphasis added.)

To similar effect, the Committee on Deep Sea Mineral Resources of the American Branch of the International Law Association has recently stated:

"The jurisdiction of coastal states with respect to the natural resources of the sea-bed and subsoil areas under the high seas is determined by the Geneva Convention on the Continental Shelf. . . .

"As a general rule, the limit of adjacency may reasonably be regarded as coinciding with the foot of the submerged portion of the continental land mass....

"In particular instances, as where there is a very narrow or ill-defined continental margin, it may be equitable to regard the limit of adjacency as extending beyond this line. In such situations, the adjacency concept gives the coastal state exclusive mineral jurisdiction in an area of deep ocean floor which is reasonable with regard to all relevant circumstances." 24

This Committee also recognized the special situation of narrow or enclosed seas, saying: "In the case of narrow or enclosed seas, the principle of adjacency might appropriately carry coastal mineral jurisdiction to the median lines, even though these are beyond the continental blocks." ²⁵

As stated by the International Court of Justice in the North Sea Continental Shelf cases between the Federal Republic of Germany/Denmark and the Federal Republic of Germany/Netherlands, decided on February 20, 1969:

". . . what the Court entertains no doubt is the most fundamental of all the rules of law relating to the continental shelf, enshrined in Article 2 of the 1958 Geneva Convention, though quite independent of it,-namely that the rights of the coastal State in respect of the area of continental shelf that constitutes a natural prolongation of its land territory into and under the sea exist ipso facto and ab initio, by virtue of its sovereignty over the land, and as an extension of it in an exercise of sovereign rights for the purpose of exploring the seabed and exploiting its natural resources. In short, there is here an inherent right. In order to exercise it, no special legal process has to be gone through, nor have any special legal acts to be performed. Its existence can be declared (and many States have done this) but does not need to be constituted. Furthermore, the right does not depend on its being exercised. To echo the language of the Geneva Convention, it is 'exclusive' in the sense that if the coastal State does not choose to explore or exploit the areas of shelf appertaining to it, that is its own affair, but no one else may do so without its express consent." 26

The "prolongation" concept is referred to by the Court as applying to the "continental shelf" without particularizing the sense in which the Court uses that term. Nonetheless, the rationale of the prolongation concept, which the Court adopts, clearly supports the NPC's view that the coastal nation has exclusive sovereign rights over the natural resources of all the submerged areas which form part of the underwater prolongation of such nation's land territory. As demonstrated in Section F of this chapter, the continental borderland, the continetal slope and at least the landward portion of the continental rise clearly constitute a part of the prolongation of the land territory of the continent. Therefore, in addition to the

^{23.} It was not necessary for the House of Delegates either to approve or disapprove this statement by the Association's Sections and Committee, which it had charged with responsibility in this matter. However, the House of Delegates did unanimously approve and adopt a resolution proposed by the two Sections and Committee (to which the quoted statement was annexed, as required by the Association's rules).

^{24.} Interim Report, July 19, 1968, pp. 1X-XI.

^{25.} Ibid., p. XVIII.

^{26.} Paragraph 19 of the Judgment.

fact that the coastal nation has exclusive natural resources jurisdiction over these areas by virtue of the text and history of the Convention, a coastal nation's exclusive right to the natural resources of the seabed and subsoil of these areas is clearly supported by the rationale of the judgment of the Court in the North Sea Continental Shelf Cases.

E. Practice of States

Some of those favoring a narrow belt of national jurisdiction have attempted to cast doubt on the general acceptability of the Geneva Convention as a statement of international law by pointing out that only 39 nations have ratified that Convention and that other nations are not bound by its terms. This approach overlooks both the fact that the parties to the Convention, including the United States, are committed to the principles which it enunciates and the fact that it has become widely accepted even by nonsignatories as embodying principles of customary international law.

To date, at least 107 nations have given recognition to the principle of coastal-state mineral jurisdiction over submarine areas adjacent to their coasts, through ratification of the Convention on the Continental Shelf, unilateral declaration, domestic legislation, regional treaty or offshore concession agreement.

Thirty-nine nations, of which all but four are coastal states, have become parties to the Geneva Convention on the Continental Shelf. Another eight nations have adopted the Convention's definition of the continental shelf in domestic legislation. Other coastal states have adopted a variety of definitions: Three define the shelf in terms of exploitability only, six claim mineral rights to a distance of 100 or 200 miles from their coastlines, one claims mineral rights to the abyssal ocean floor, and eight have adopted other definitions. Twenty-three nations (including the Persian Gulf States) have adopted a shelf concept in general legislation or proclamations, but no precise definition. In 19 other nations there has been either offshore activity, or concessions have been granted, without enactment of general legislation. Of the 107 coastal nations which have asserted their general jurisdiction over offshore minerals, at least 37 have done so with respect to specific submarine areas which, according to available information, appear to be beneath waters deeper than 200 meters. In most cases (29), this has been done by the issuance of deepwater leases; in others by decree, legislation, announcements of national policy, or agreement with neighboring states, or offers of such agreements. A complete list of the positions held by these various nations appears in Appendix F.

As stated by the Committee on Deep Sea Mineral Resources of the American Branch of the International Law Association, in speaking of the jurisdiction of the coastal states under Article 1 of the Geneva Convention:

"The basis for this recognition of exclusive mineral jurisdiction is twofold: the predominant interest of the coastal state in the bed of the sea adjacent to its shores, and the necessity for certainty as to what law is applicable to that sea-bed. To date, some three-score nations have given recognition to the principles of that Convention, 36 by ratifying it, [27] the others by adopting major provisions of it in domestic legislation or regional agreements. From the wide acceptance of the principles set forth in the Convention, even by states which are not parties, it is clear that they constitute part of customary international law." 28

Certainly, the Senate Foreign Relations Committee attached major significance to the Geneva Convention when it stated in its report at the time of ratification in 1960 that:

"The continental shelf as a legal concept gained impetus with the Truman Proclamation of September 1945, which announced that the United States regards the natural resources of the subsoil and the seabed of the continental shelf beneath the high seas but contiguous to the coasts of the United States as subject to its jurisdiction and control. By 1956 some 20 states had made claims with respect to the shelf. The Convention on the Continental Shelf converts this state practice into codified international law." ²⁹ (Emphasis added.)

And again, quoting from a list of benefits accruing to the United States pursuant to the law of the sea conventions as furnished by the Department of State:

"The Convention on the Continental Shelf is particularly significant and beneficial to the United States which is one of the principal countries making use of the natural resources of the shelf because the convention reflects for the first time international agreement on the rules governing the exploration and exploitation of this vast submarine area of the world. The convention should prove specially beneficial to the United States since it endorses numerous principles which the United States has been following since they were enunciated in the 1945 proclamation of President Truman concerning the Continental Shelf." 30

Now 39, through the recent addition of Sierra Leone, Thailand, and Trinidad-Tobago.

^{28.} Interim Report, op. cit., p. IX.

^{29.} Senate Executive Report No. 5, 86th Cong., 2nd sess., p. 8.

^{30.} Ibid., p. 11.

While reference is made in these quotations to the Truman Proclamation of September 28, 1945, entitled "Policy of the United States with Respect to the Natural Resources of the Subsoil and Sea Bed of the Continental Shelf" (10 Fed. Reg. 12303), as the starting point of the legal concept on which national jurisdiction over the natural resources of the adjacent seabed is based, it is apparent that there has been no intent to freeze the concept to 1945 thinking.

It is a fact that the Truman Proclamation asserted U.S. jurisdiction and control over the natural resources of "the subsoil and sea bed of the continental shelf beneath the high seas but contiguous to the the coasts of the United States," without further definition or delimitation of that term. It is also a fact that the accompanying White House press release issued the same day stated that "Generally, submerged land which is contiguous to the continent and which is covered by no more than 100 fathoms (600 feet) of water is considered as the continental shelf."

It must be remembered, however, that as of the date of the Truman Proclamation not one well had been drilled beyond the 3-mile limit. With the increasing interest in the total resources of the continental margins that developed between 1945 and 1956, and the resultant trend away from the strict geological concept of the continental shelf as the outer limit of coastal-nation jurisdiction, the United States was prepared by March of the latter year to align itself with 19 other American states in the Ciudad Trujillo conclusion that the seabed and subsoil of the entire continental and insular terrace of the American states and of other submarine areas adjacent to the coast and capable of exploitation appertained exclusively to the states concerned and were subject to their jurisdiction and control.

As previously noted, when Acting Secretary of State Dillon transmitted the Geneva Convention to President Eisenhower for ratification on September 2, 1959, he clearly noted the departure from the narrow concept of 1945, stating that the Geneva Convention "combines both the depth and exploitability tests as did the International Law Commission draft," 31

Canada is one of the nations that is not a formal adherent to the Geneva Convention but which appears to have shaped its views of national jurisdiction along the lines of that Convention. Thus, at the March 11, 1968 meeting of the U.N. Ad Hoc Committee to Study the Sea-Bed and Ocean Floor Beyond the Limits of National Jurisdiction the spokesman for Canada said:

"In the view of the Canadian authorities, the present legal position regarding the sovereign rights of the coastal States over the resources of submarine areas extending at least to the abyssal depths is not in dispute." 32 (Emphasis added.)

Again, on March 21, 1968, the Canadian spokesman expressed himself in words which have been reported as follows:

"The [Ad Hoc] Committee should define the limits of the area covered by the resolution [Gen. Ass. Res. 2340 (XXII)]. In his (i.e., the Canadian spokesman's) view, the areas over which coastal States had sovereign rights included, without doubt, the continental shelf and its slope." 33 (Emphasis added.)

The explanation of this interest of the Canadian Government in the full extent of the national rights confirmed by the Geneva Convention is found in the following statement of their representative to the Economic and Technical Working Group of the U.N. Ad Hoc Committee mentioned above:

"Who would have thought that we would have advanced to our present stage of knowledge and technology since the Law of the Sea Meetings in Geneva of only a decade ago? Not even those who drafted the Convention on the Continental Shelf.

"Certainly, we in Canada could not have predicted that during this time exploration activity off our coasts would progress so rapidly. We could not have predicted that exploratory surveys for oil and gas would be carried out on our shelf areas to distances up to 300 miles from our coasts. We could not have predicted that exploratory test drilling would be carried out off our coasts in depths of water up to and exceeding 3,500 feet. And we could not have predicted that deep exploratory wells would be drilled on our shelf areas for distances up to 175 miles from our coasts. Yet all these things have happened. Moreover, the Canadian Government is carrying out offshore research studies and scientific investigations that could not have been foreseen a few years ago, for example, on such features as the Flemish Cap, a shelf projection some 350 miles east of Newfoundland, and the San Pablo Seamount, one of the Kelvin Seamounts about 400 miles south from Nova Scotia.

"If many of these things would have seemed far fetched or even fantastic a decade ago, who can say then what the expectations are for the future? . . . "34

The Presidium of the U.S.S.R., on February 6, 1968, promulgated a decree which, after paraphrasing Article 1 of the Convention on the Continental Shelf, stated:

"The sea-bed and the subsoil of depressions entirely surrounded by the continental shelf of the

^{31.} Digest of International Law, loc. cit. 32. U.N. Document No. A/AC,135/1, p. 33.

^{33.} U.N. Press Release GA/3585, p. 2.

^{34.} Release by the Canadian Mission to the United Nations, June 25, 1968, pp. 1-2.

U.S.S.R., irrespective of their depth, are part of the continental shelf of the U.S.S.R." 55

While the U.S. Government has not yet issued leases as far out as the outer edge of the continental margin, it has, by actions taken by the Department of the Interior, clearly evidenced its construction that the definition of national jurisdiction extends far beyond the 200 meters water-depth line. In 1961, the Associate Solicitor of the U.S. Department of the Interior issued a memorandum opinion concluding that the Secretary's leasing power under the Outer Continental Shelf Lands Act, read in light of the Convention on the Continental Shelf, extends to an area lying about 40 miles off of California in water depths ranging up to 4.020 feet (1,225 meters) with the greater part being in excess of 600 feet (183 meters). In June 1967, the Solicitor of the Department of the Interior, in commenting on this memorandum opinion, stated: "The opinion was submitted to the Departments of State and Justice to determine if they had objections and they registered none." 36 The Secretary has also issued oil and gas leases in water depths up to about 1,800 feet (549 meters).

Moreover, the Secretary of the Interior announced in June 1965, that he had authorized approval of plans of a company to conduct a core drilling project on the continental slope in the Gulf of Mexico off the coasts of Texas, Louisiana and Florida in waters ranging in depth from 600 to 3,500 feet (183-1,067 meters). This "permit" or authorization is not to be confused with the grant of an oil and gas or other mineral lease. It appears that this permit was issued pursuant to Section 11 of the Outer Continental Shelf Lands Act and the Secretary made clear in the permit that "No rights to any mineral leases will be obtained from these core drilling programs." Also, on May 26, 1967, the U.S. Geological Survey announced approval of plans for another company or group of companies to conduct a core drilling program on the continental slope beoynd the continental shelf "off Florida and northward to points seaward of Cape Cod and Georges Bank." The release states that "No rights to any mineral leases will be obtained from these core drilling programs." The release indicates that about 21 core holes will be drilled beneath the floor of the Atlantic Ocean in water depths from 650 to 5,000 feet (198-1,524 meters). The depth of penetration in each core test is limited to a maximum of 1,000 feet (305 meters). Both of these projects have now been carried out.

In a letter opinion of February 1, 1967, from the Deputy Solicitor of the Department of the Interior to the Corps of Engineers, it is made clear that the Department is of the view that Cortez Bank is an area under U.S. jurisdiction under the Outer Continental Shelf Lands Act and the Convention on the Continental Shelf. Cortez Bank is located about 100 miles from the California mainland and is separated from the mainland by ocean floor trenches as much as 4,000 to 5,000 feet (1,219-1,524 meters) deep, although the Bank itself is covered by shallow water. One of the items before the Department when it arrived at this conclusion was a published scientific report showing that the Bank was an extension of the land mass of Southern California.³⁷

The Under Secretary of the Department of the Interior, Charles F. Luce, made the following statement in an address before the ABA on the Development of Ocean Minerals and the Law of the Sea:

"The United States has taken action consistent with a claim of sovereign rights to the seabed and subfloor some distance from its coasts, by the granting of a phosphate lease some 40 miles from the California coast in the Forty-mile Bank area in 240 to 4,000 feet of water; by the granting of oil and gas leases some 30 miles off the Oregon coast in about 1,500 feet of water; and in the threatened litigation against creation of a new island by private parties on Cortez Bank about 50 miles from San Clemente Island off the coast of California or about 100 miles from the mainland. Each of the California areas is separated from the coast by troughs as much as 4,000 to 5,000 feet deep. The Department of the Interior has published OCS leasing maps indicating an intent to assume jurisdiction over the ocean bottom as far as 100 miles off the Southern California coast in water depths as great as 6,000 feet." 38

F. Geological Basis for Outer Boundary of Exclusive Coastal-State Jurisdiction Over Bottom Mineral Resources

The intention of the drafters of the Geneva Convention to establish, as a general guideline of the outer limit of exclusive coastal-state jusisdiction over bottom mineral resources, a line coinciding approximately with the outer limit of the submerged continent, is not only in keeping with the actual language used in the Convention but also finds eminent justification in the fact that this is the most distinct, the most profound, and the *only natural* boundary which can be utilized for this purpose.

 [&]quot;Survey of National Legislation concerning the sea-bed and the ocean floor, and the subsoil thereof, underlying the high seas beyond the limits of present national jurisdiction." U.N. Document No. A/AC.135/11, June 4, 1968, p. 58.

F. Barry, "The Administration of the Outer Continental Shelf Lands Act," Natl. Resources Lawyer, vol. 1, No. 3, July 1968, p. 38.

^{37.} Ibid.

^{38.} National Institute on Marine Resources, June 8, 1967, p. 4.

The surface of the earth, regardless of water cover, can in a broad way quite readily be divided into two fundamentally distinct geomorphic units-the ocean basins and the continental platforms. These, moreover, are a surficial reflection of fundamental lateral differences in the geological/geophysical character of the earth's crust down to the mantle. Geophysical investigations have established that the mantle is made up of rocks of high density and high seismic velocity, probably of ultrabasic chemical composition. Floating in this mantle material are huge masses continents-of less dense, dominantly granitic rock of lower seismic velocity, which, like icebergs in the sea, because of their lower relative density, not only tend to stand up prominently above the general level but, also like icebergs in the sea, extend downward deep into the mantle material. The fundamental distinctions between the crust of the continental domain versus that of the oceanic domain are, thus, (1) higher surface elevation, (2) greater depth to mantle, (3) greater thickness, (4) lesser density, (5) lower seismic velocity, and (6) probably more acidic (sialic) rather than basaltic (mafic) rock composition.

The lateral change from oceanic to continental crust is impressively sharp—when viewed on an overall world scale.

Actually, however, it often takes place only in a broad zone many kilometers or hundreds of kilometers wide, and in detail is often obscured by transition zones or confused by structural complications and other local anomalies. Moreover, most of its distinguishing features, enumerated above, are determinable only through geophysical measurements or inferences from geophysical data, which are often subject to varying interpretation. Thus while fundamentally valid, the change between continental and oceanic crust does not constitute a precise boundary despite its immense value as a general guide to such a boundary.

One reflection of this crustal change, however, is readily discernible at the surface and this is the topographic boundary scarp resulting from the physical tendency of the continental masses to stand high relative to adjacent oceanic areas. This scarp is known as the *continental slope*—the frontal edge of the continental shelf. The continental slope has been picturesquely described as "the greatest topographic feature on the face of the earth, an escarpment 3.5 km. high and over 350,000 km. in length, which is in turn the surface expression of the greatest structural discontinuity on the earth's surface, the transition from continental to oceanic crust." ³⁹ Again, it has been called "by far the steepest, longest, and highest topographic feature on the earth's surface." ⁴⁰

The slope commonly is about 15-30 km. in width and has an inclination of about 2°-6°, but is occasionally as steep as 20°-30° or more. It commonly has a height of about 3,000 meters but in some areas, as along the west coast of South America, persistently maintains heights of as much as 8,000 meters. In detail it is quite variable in width, height, and steepness and in some parts of the world it was either never well developed or it has been obscured by sedimentation. Nevertheless, the slope remains the sharpest and most persistent natural feature of the earth's surface and its base corresponds closely in position with the most fundamental lateral variation in the character of the rocks of the earth's crust-the change from oceanic to continental character. Granting, of course, that there are places where there is no pronounced topographic expression of the oceanic-continental crustal boundary, and granting that there are places where the lateral change from oceanic to continental crust is vague or a transitional crust appears to exist; still, the generally worldwide extent of this fundamental crustal change and its common surface manifestation as the continental slope, provide a much-needed, appropriate, and both technically and legally sound basis for the demarcation of the seaward limit of exclusive jurisdiction by coastal states over the mineral resources lying on and beneath the ocean floor.

The extent and practical significance of this longrecognized natural boundary between continental and oceanic areas has recently been touched on further by Emery, Pecora, Worzel, and Hedberg.^{‡1} It is recognized that the base of the continental slope is the reflection of a far more fundamental feature than is the edge of the geological continental shelf; and it is recognized that it is the base of the continental slope, not the edge of the geological continental shelf, which should be used as a guide to the outer

 [&]quot;Opportunities and Problems in Marine Geology and Geophysics," *Marine Geology*, vol. 3, (Intergovernmental Ocean Comm., 1965), pp. 227-41.

R. S. Dietz, "Origin of Continental Slopes," American Scientist, Vol. 52 (1964), pp. 50-59.

K. O. Emery, "Geological Aspects of Sea-Floor Sovereignty," The Law of the Sea, Lewis M. Alexander, ed. (Ohio State University Press, 1967), pp. 139-59.

H. D. Hedberg, "Why Explore the Deep Offshore?" Exploration and Economics of the Petroleum Industry, vol. 5, (Dallas: Int. Oil and Gas Educational Center, The Southwestern Legal Foundation. 1967), pp. 61-84.

^{, &}quot;The Future of the Petroleum Industry In the Oceans," (Paper presented at Conference on Industry's Future in the Oceans, Miami, Florida, 1968), 16 pp.

^{, &}quot;Some Matters of Concern to the Petroleum Industry with Respect to Public Policy on Mineral Resources of the World Ocean," (Paper presented at Symposium on Mineral Resources of the World Ocean, Newport, Rhode Island, July 1968), 21 pp. W. T. Pecora, "Geologic Boundary of the Continents," Statement by the Director, U.S. Geological Survey, February 21, 1968, 2 pp. J. Lamar Worzel, "Survey of Continental Margins," Geology of the Shelf Seas, D. T. Donovan, ed. (Edinburgh: Oliver & Boyd, 1968), pp. 117-52.

edge of the continental block. Moreover, since the plunge of the slope has often been locally overlapped extensively by the sediments of the continental rise, a boundary just oceanward of the base of the slope, to include the shelf, the slope, and the landward portion of the continental rise, where developed, most closely approaches the true ocean-bottom boundary between continental and oceanic areas and is the most natural and appropriate outward limit of a country's sovereign rights over bottom resources. A boundary thus drawn gives recognition to the natural oceanward extension of the domain of each coastal nation and the inclusion under its

jurisdiction of that suboceanic territory over whose natural resources the coastal nation is most practically suited to exercise control.

In summary, given a recognition of the above scientific facts, it is apparent that the outer edge of the continent is a far more logical choice than the outer edge of the geological continental shelf as the limit of coastal-nation exclusive jurisdiction over the natural resources of the seabed and subsoil. The participating nations at Ciudad Trujillo in 1956 and at Geneva in 1958 wisely declined to limit the coastalnation's exclusive jurisdiction to the geological continental shelf or to the 200-meter isobath.

CHAPTER SEVEN—IMPLEMENTATION OF UNITED STATES POLICY OBJECTIVES CONSISTENT WITH THE 1958 CONVENTION ON THE CONTINENTAL SHELF

A. Objectives: The Protection of the American Mineral Estate

The primary objective of American policy with respect to submarine minerals should be to protect this segment of the American mineral estate to the maximum extent possible against international encroachment now threatened.¹ The secondary, and less urgent, objective should be the establishment of arrangements to govern exploration and exploitation of minerals of the abyssal ocean floor seaward of the areas of exclusive jurisdiction of coastal nations. This chapter discusses means of attaining the first objective; chapter 8 discusses the second.

As discussed in chapter 6, the wording of the Geneva Convention on the Continental Shelf, the history of its preparation, its interpretation by the

This has been admirably stated in a unanimous resolution of the House of Delegates of the ABA: "That within the area of exclusive sovereign rights adjacent to the United States, the interests of the United States in the natural resources of the submarine areas be protected to the full extent permitted by the 1958 Convention on the Continental Shelf." (Resolution No. 73, August 1968).

United States at the time of ratification, prevailing current legal opinion, the practice of the United States and other coastal states, and geological and geographical considerations, all combine to make it clear that the legal, natural, and appropriate limits of U.S. sovereign rights over the natural resources of the sea bottom extend out to the edge of the submerged continent, irrespective of depth of water or distance from shore. It is the duty of the U.S. Government to assert these rights and to maintain them in full. Acceptance of any lesser result would be the giving away of rights already confirmed to this Nation by the Convention on the Continental Shelf and a giving away of potential resources essential to the future welfare and security of this country.

A current threat to the exclusive sovereign rights of this country to the minerals of the submerged continent stems from the Maltese proposal in the General Assembly of the United Nations to establish an international regime which, by treaty, would become the owner of the minerals beneath the sea beyond the limits of national jurisdiction. In consequence of this proposal, the matter of deep-sea minerals was given active consideration during 1968 by a 35-nation Ad Hoc Committee established by the U.N. General Assembly and will be the subject of continuing consideration by a permanent committee established by the U.N. General Assembly in December 1968. Since the Geneva Convention on the Continental Shelf, by the terms of Article 13, can be made subject to amendment by its parties after June 10, 1969, it is clear that the United States faces the necessity for early and major policy decisions. The primary question is whether the United States shall stand on the rights now assured it by the Convention, or acquiesce in new negotiations which might result in at least partial derogation of those rights in favor of some new international regime.

The magnitude of the U.S. national asset in offshore petroleum is discussed in chapter 2. The stake of the people of this Nation in the retention of U.S. jurisdiction over the minerals of the submarine portion of this continent cannot be accurately evaluated, because only a small fraction of it has been drilled. But, based on experience from operations in the small percentage of the continental margin explored to date, the value at the wellhead of the petroleum which will ultimately be produced from the areas at stake can be estimated in tens of billions of dollars. Of this, a high proportion will accrue to the Federal treasury in taxes, bonuses, and royalties.

The Federal treasury has an important stake in the geographical extent of American jurisdiction over petroleum resources. The U.S. Treasury derives substantial revenues from petroleum production from

federally owned land. These revenues, in addition to general income taxes, are made up of bonuses paid to the Government in competitive bidding on leases and royalties on production. A very high proportion of these revenues is derived from the offshore. For example, up to the end of 1968 the U.S. Treasury had received about \$4 billion from offshore petroleum bonuses and royalties. In a single 12-month period ending in June 1968, it received \$1.7 billion from its submerged lands, an amount greater than the total which the Federal Government has received from its onshore petroleum leases in the entire 48-year period since the enactment of the 1920 Mineral Leasing Act. Manifestly, it is to the interest of the Federal treasury to maintain the maximum geographical extent of U.S. jurisdiction over the mineral resources of the submerged portion of the continent.

It is desirable that the parties to the 1958 Convention, with such additional nations as care to join them, promulgate parallel uniform declarations, stating the extent of their claims (and the limitations on those claims) under the 1958 Convention on the Continental Shelf.2 Its purpose should be to assert (and, in general, limit) claims on coastal jurisdiction to the edge of the continent in order to put at rest the conflicting contentions (a) that coastal jurisdiction under the Convention extends to the median lines of the oceans, and (b) that coastal jurisdiction excludes all recourse to the exploitation criterion of the Convention. For the purpose of drafting such a declaration, our Government should take the lead in conferring, first, with this Nation's American partners with whom it participated in the unanimous 1956 Ciudad Trujillo declaration of 20 American states, and next with others of the 34 coastal nations which have joined with the United States in ratifying the 1958 Convention.

B. Comments on Some Recent Proposals Which Are Deemed Objectionable

 A Renegotiation of the 1958 Convention on the Continental Shelf With Respect to Natural Resource Jurisdiction Is Wholly Undesirable.

Since the Convention, as it now stands, recognizes exclusive U.S. jurisdiction over each new oil or gas well which establishes exploitability of the Nation's submerged continent, and will continue to protect that jurisdiction to the outer edge of the submerged continent, neither a new convention nor

Such action is not without precedent. The 1954 International Convention for the Prevention of Pollution of the Seas by Oil was subsequently clarified in 1962 by the Conference of Contracting Governments, signed by 29 of the original 38 participants in that Convention.

any amendment to the present Convention is necessary or desirable with respect to submarine petroleum resources.3 The negotiation of a new convention might literally open Pandora's box, possibly involving lengthy discussions by other nations about disposing of a great part of the U.S. mineral estate, which they do not own. Even if the proceedings were limited to the 39 parties to the present Convention, no advantage to the United States could accrue because it has vested rights thereunder which we feel should not be sacrificed. No doubt some of the 39 parties would resist an amendment which diminished the geographical extent of exclusive coastal jurisdiction, because they themselves are coastal nations. Indeed, some 100 of the 126 members of the United Nations are coastal. Logically, such an amendment could expect only the support of the landlocked nations, plus those coastal nations which have no hope of any significant discovery of minerals off their coasts.4 It would be manifestly unwise for the United States to subscribe to such a change, forsaking a substantial portion of its own mineral estate, while other coastal nations did not.

At the other extreme, any proposal to amend the 1958 Convention to expand coastal jurisdiction seaward beyond the edge of the submerged continent would have no likelihood of acceptance by the world community.

"Intermediate Zone" Proposals Are Unacceptable.

Various concepts and recommendations for the establishment of an "intermediate zone" have been carefully considered and such propositions are rejected.

Predominant among these proposals is one that the seaward limit of a coastal state's "continental shelf" should be fixed at the 200-meter isobath, or 50 nautical miles from the baselines for measuring the breadth of its territorial sea, whichever alternative gives the coastal state the greater area for permanent, exclusive mineral resource exploration and exploitation.5 "Intermediate zones" would then be created encompassing the bed and subsoil of the deep sea (i.e., the submarine areas beyond the continental shelves as redefined) to the 2,500meter isobath, or 100 nautical miles from the baselines for measuring the breadth of each coastal state's territorial sea, whichever alternative gives the coastal state the greater area for the purposes for which the intermediate zones are created. This proposition provides that only the coastal state or its licensees, which may or may not be its own nationals, would be authorized to explore or ex-

ploit the mineral resources of the intermediate zone. However, such exploration and exploitation, including the terms thereof, would otherwise be governed by a new international legal/political framework applicable to the deep-sea areas beyond the intermediate zone. This new framework calls for the payment to go to an International Fund of such portion of the value of the production as shall be fixed by an International Registry Authority. Such payment to go to the International Registry Authority on behalf of the International Fund is designed to take the place of both the fixed annual rent per acre or square mile and the royalties on the value of production which must now be paid under mineral leases on the outer continental shelf. This payment for the International Fund, which the International Registry Authority will fix, may be greater or less than the combined rents and royalties paid to the coastal nation for the same mineral value extracted from the outer continental shelf.

We disagree with proposals of such nature. In the first place, they are contrary to the Convention on the Continental Shelf. Moreover, if the United States adopted such proposals, as a matter of its own policy, it would thereby deprive itself, in amounts to be fixed by an International Registry Authority, of anticipated revenues from minerals in the American continent beyond water depths of 200 meters, or 50 miles from the coast, and give up substantially all, if not all, jurisdiction and royalties beyond a water depth of 2,500 meters, or 100 miles from the coast. Meanwhile, during the long interim period while such proposed arrangements are being negotiated, the United States would be subjecting present and future lessees and operators in the "international zone," including its "intermediate zone," to the hazard that the new international regime (a) would increase the royalty rates or otherwise adversely change the terms of the contract initially made between the U.S. Government and such lessee or operator, and (b) would decline to renew the rights of such operator, or insist on adverse renewal terms.

Article 13 of the Convention makes it eligible for amendment after June 10, 1969.

^{4,} Few, if any, coastal nations would seem to be devoid of such hopes. Some form of law, decree or international agreement, regulating development of submerged offshore minerals, has been put into effect by 107 coastal nations (see Appendix F).

^{5.} See, e.g., Our Nation and the Sea, the report of the Commission on Marine Science, Engineering and Resources, Chapter 4, Part III, pp. 141-57, where one of these proposals is advanced. The National Petroleum Council report herein differs with that specific proposal by the Marine Sciences Commission and also differs with a number of other proposals advanced in that Commission report, as will be evident from a comparison of the Conclusions and Recommendations of the two reports.

"Retroactive Boundary" Proposals Are Adverse to United States Interests.

In June 1968, a U.S. representative proposed certain "principles" to the U.N. *Ad Hoc* Committee. Among them were the following:

"3. Taking into account the Geneva Convention of 1958 on the Continental Shelf, there shall be established, as soon as practicable, an internationally agreed precise boundary for the deep ocean floor—the sea-bed and subsoil beyond that over which coastal States may exercise sovereign rights for the purpose of exploration and exploitation of its natural resources.

"Exploitation of the natural resources of the ocean floor that occurs prior to establishment of the boundary shall be understood not to prejudice its location, regardless of whether the coastal State considers the exploitation to have occurred on its 'continental shelf'." (Emphasis added.)

If the italicized language were coupled with a firm assertion by the United States of its jurisdiction over the natural resources of the entire submerged continent and a declaration of its intention to stand on its rights in this regard under the Geneva Convention, there would be no need to be unduly disturbed by this proposal. However, in view of the efforts in many quarters to cut back on the national jurisdiction of the United States under the Geneva Convention, the italicized statement places a cloud on the title of every lease made by the United States beyond the 200-meter isobath and will serve as a substantial deterrent to industry investment in deep waters and further development of equipment for deepwater exploration and exploitation. The fact that the statement has been made emphasizes the necessity of an early declaration by the U.S. Government of its rights under the Geneva Convention and its intention to stand on those rights.

The suggestion has been made that the Congress should enact legislation to compensate private enterprise for "loss of investment or expenses" occasioned by any new international framework that redefines the continental shelf so as to put the area in which it is engaged in mineral resources development beyond the shelf's outer limits. This suggestion is not attractive to the petroleum industry, and in all likelihood would not be acceptable to the U.S. Congress, as a substitute for the present provisions of the Outer Continental Shelf Lands Act, which assures security of tenure to the lessee, and assures that all royalties will go into the Federal treasury.

C. The Rights of Other Coastal Nations

Two consequences, involving foreign coastal nations as well as the United States, follow from the identification of the exclusive jurisdiction of the coastal nations with the submerged boundaries of the continents.

All Coastal Nations Have the Same Rights as Those Vesting in the United States.

Petroleum operations conducted by a U.S. national on a foreign continental margin must be licensed by the adjacent coastal nation, and cannot be conducted free of control by any national jurisdiction. It has been suggested that this would be undesirable to the U.S. petroleum industry. The argument, which is rejected, is that (1) the petroleum industry could deal with an international regime off a given foreign coast more advantageously than with the coastal nation regime, whose laws might be unstable, and that, (2) to obtain this advantage to the petroleum industry, it should support the cession of jurisdiction over minerals in the seaward portion of the submerged American continent to that international regime.

In the first place, the question is what is in the overriding interest of the United States, not what is in the interest of the petroleum industry.

Assuming, arguendo, that an international regime might grant the industry better terms than would a foreign coastal nation, the American petroleum industry, nevertheless, emphatically refuses to endorse trading off to an international regime any U.S. interest in the American offshore mineral estate in order to obtain advantages for the industry abroad.

In the second place, the argument for such a trade is highly unrealistic, on two counts. For one thing, there is virtually no conceivable chance that any foreign nation, with good prospects for mineral resources off its coast, would renounce one iota of the rights vested in it by the Geneva Convention no matter how magnanimous the United States was in relinquishing its own rights. For another thing, recent trends within the United Nations give little reason for hope that American nationals would fare better under a regime formulated by a 126-nation forum in which the United States has one vote, than they would fare dealing with individual nations under their national laws. And those who negotiate with individual nations are dealing with those national agencies most capable of determining and safeguarding their own national interests.

Petroleum Operations on the Submerged Portion of the United States Continent Cannot

be Licensed by any Foreign Government or International Entity.

If mineral operations are sought to be conducted on the U.S. continental margin by a foreign company or government, they are subject to exclusion or licensing by the U.S. Government. In the latter event, the U.S. Government is, and ought to be, exclusively entitled to all bonus, royalty, and like revenues.

D. Demarcation of Boundary of Coastal-Nation Seabed Jurisdiction

Manifestly, the problem of demarcation of the line of national jurisdiction on the deep-ocean floor is a most difficult one, no matter how the boundary is described. This is inherent in the Convention's concept of national jurisdiction as being limited by the principle of "adjacency," which, as noted before, is taken herein to be a limitation on claims of jurisdiction which otherwise could be asserted without seaward limit if they were only controlled by the Convention's other criterion of jurisdiction—"exploitability."

Distinctive as is the base of the continental slope—the most distinctive geomorphic feature of the ocean floor (as discussed in chapter 6)—it is far from being a sharp enough feature to serve as a precise political or economic boundary line. The base of the slope, significant as it is, can serve only as the most important surface guide to any jurisdictional boundary which is to be controlled by the seaward extent of the continents—not as the boundary itself but as a guideline to the boundary.

After accepting the logical principle of a boundary corresponding approximately with the submerged edge of the continent, the problem of demarcation of a *precise* boundary to the jurisdictional area of the coastal state over bottom resources still remains. This is a difficult problem but one which, as has been said, will not simply go away because we do not face it. Moreover, in general it is better to agree upon boundaries before, rather than after, possible economic developments complicate the situation.

Many suggestions have been offered as to how this boundary should be defined. Most commonly, a certain water depth has been proposed—550 meters, 2,500 meters, 5,000 meters, and so on. Others have proposed a certain distance from shore—25 miles, 50 miles, 100 miles, 200 miles, and so on. Still others have suggested a combination of distance and depth. All of these, however, yield only purely arbitrary boundaries without any consistent relation to the fundamental guideline of the edge of the continent.

Moreover, neither a fixed water depth nor a fixed

distance from shore nor a combination of the two will ever in itself provide a satisfactory boundary. Not only is it impracticable to make a boundary line follow a bathymetric contour or a line representing a fixed distance from shore but also neither of these represent positions which are constant in time. For example, one need only consider the difficulties which would be involved in a boundary between countries or mineral leases on land, drawn on a topographic contour, to realize how unsuitable a bathymetric boundary at sea would be.

No specific fixed solution to this problem of precise boundaries is proposed herein. There may be a number of practicable schemes, and a conference between coastal nations on this matter would seem desirable. It is believed, however, that what should be insisted upon is that whatever precise boundaries are eventually drawn should be such as to assure a fair and reasonable approximation of the outer edge of the submerged continent. This can only be done by making certain that the boundary lies out sufficiently beyond the present base of the continental slope to include the landward portion of the continental rise where it overlaps the slope.

Another point seems crystal clear. In the long run, the only practical and effective means of indicating an unequivocal and enduring subsea boundary will be by means of straight lines connecting fixed points defined by geographic coordinates of latitude and longitude, related to a widely accepted standard base, and corresponding generally to the submerged edge of the continent.

One suggested solution to the precise boundary question which may be worthy of serious consideration is for each coastal state to draw its own boundaries, based on coordinates of latitude and longitude, within broad guidelines to be agreed upon at a conference of coastal nations attended by technical experts. These guidelines might specify a zone seaward from the base of the slope within which the exact boundary should be drawn. Similarly, where that slope is not developed they might indicate a broad zone based on water depths and/or distance from shore within which the line should be drawn.

The problem of demarcation, then, ought to be approached as a scientific or technical problem once the guidelines are agreed upon. Precise demarcation should therefore be undertaken by a competent scientific or technical agency of international composition. Several prototypes now exist.

The proposed scientific or technical agency could also be charged with proposing a formula comparable to that suggested above for the establishment of boundaries off precipitously dropping continental margins, such as some of those off Alaska and the west coast of South America, recommending whatever maximum distance from the outer edge of the continent or the coastline that seemed to best fit the intention of the drafters of the Convention to provide equitable treatment to, and protect the interest of, the coastal nations in such cases.

It might also suggest general guidelines for identification of the semienclosed seas whose subsea resources might reasonably be claimed in their entirety by the adjacent coastal nations and divided among themselves in accordance with Article 6 of the Convention.

In the case of islands, which the Convention accords the same treatment as continents, Article 6 of the Convention makes adequate provision for the settlement of disputes between adjacent islands, or between islands and adjacent coastal nations of different nationality, but here again the proposed technical agency might well be able to come up with proposals consonant with the general provisions of the Convention that would minimize the number of such disputes and facilitate their resolution when they do arise. In any event, the jurisdictional problems relating to insular margins is peripheral to the main problem, which is jurisdiction over continental margins.

Guidelines such as these would allow each coastal

nation to incorporate, in large part, within its jurisdiction those resources contained within its coastal margin, while at the same time leaving the great bulk of the ocean bottoms-approximately 80 percent of the total ocean area of the world-outside of exclusive coastal-state jurisdiction. Moreover, guidelines such as these would have the advantage of providing for the claims of those states fronting on steep slopes with very narrow shelves as in the case of western South America. Finally, the procedure here suggested would have the great practical advantage of leaving to each individual state the fixing of its own boundaries in detail and within the prescribed guidelines without having those exact boundaries prescribed for it by some outside entity.

Pending such demarcation by an international technical or scientific agency, a workable interim solution would be the promulgation by each coastal nation of maps delineating its identification of the submerged edge of the continental land mass, subject, in the event of challenge, to subsequent examination and determination by an agreed international scientific agency. Specification of this agency might be included in the parallel declarations of the coastal nations proposed earlier in Section B of this chapter.

CHAPTER EIGHT—REGIME OVER OCEANIC AREAS BEYOND LIMITS OF EXCLUSIVE NATIONAL RESOURCE JURISDICTION

This chapter is generally concerned with: (1) the present status of applicable rules and principles of international law pertaining to the seabed under the oceans seaward of the "continental shelf" areas which are under exclusive national resource jurisdiction of coastal states; and (2) recommendations as to future arrangements regarding mineral exploration and development in those areas.

The area of concern is that seaward of coastal states' exclusive jurisdiction as established by the Geneva Convention on the Continental Shelf and as described in chapter 6. Generally, the line of demarcation between the area under coastal-state jurisdiction and the deep-ocean areas is taken to be where the submerged portion of the continental mass meets the abyssal ocean floor. These deep-ocean areas of the world include more than 80 percent of the earth's oceans and 56 percent of the earth's entire surface. By comparison, the submerged portion of the continental masses comprises less than 20 percent of the earth's ocean area.

A. Applicable Rules and Principles of International Law

Prefatory to any discussion of rules and principles of international law as they may relate to seabed and subsoil areas under the high seas, it should be recognized that these rules and principles were developed with reference generally to the high seas themselves and not with regard to any rights in the seabed and subsoil thereunder. Indeed, in 1958 at the Conference on the Law of the Sea, it was considered premature to consider the status of the seabed under the high seas. These rules and principles do, however, offer helpful guidelines to analysis of that status in the light of contemporary developments.

The basic international legal principle of freedom of the high seas is well defined and universally accepted. Article 2 of the 1958 Convention on the High Seas provides in part:

> "The High Seas being open to all nations, no State may validly purport to subject any part of them to its sovereignty...."

Consideration under international law of the status of the seabed has drawn into question whether it is to be treated as res nullius, i.e., property of no one and thus in principle subject to national appropriation, or res communis, i.e., property of all and not subject to national appropriation.

Review of the authorities indicates a substantial difference of opinion as to whether the seabed is properly characterized as res nullius or res communis. Since these concepts were articulated with a view toward relatively limited uses of the seas, largely navigation and fishing, and without regard to or even knowledge of a technology that would support extensive activities on the seabed designed to find and recover mineral resources, their relevance to such activities is open to serious question. However, most writers who have expressed themselves on the subject, including the ILC's Special Rapporteur on the Law of the Sea, regard the subsoil of the high seas as being capable of at least temporary occupation for scientific and economic activities on condition that there be no unreasonable interference with the free use of the superjacent high seas.2

Even should it be concluded that the seabed is not open to "occupation" in the sense of acquiring political sovereignty over territory, it would not follow that activities on or in the deep seabed, such as resource extraction, would be prohibited by international law. Political sovereignty over a seabed area is not a prerequisite for obtaining access to resources therein, regardless of whether a nation or entrepreneur utilizes mobile surface facilities, requiring only

temporary presence in an oceanic area or needs semipermanent installations on the seabed.

The immediate question then is the international lawfulness of such exploratory and exploitative activities, i.e., whether minerals of the subsoil may be removed and claimed by a single nation. On this point, one authority concludes that:

"... it would be difficult for anyone to justify physical interference with the operation, or to challenge the miner's title to the minerals extracted or to their proceeds. As a practical matter, then, on the *res communis* view of the law, he who digs could probably successfully keep." ³

The Permanent Court of International Justice in discussing the exercise of jurisdiction by a state concluded that international law left states considerable discretion, limited only in certain cases by prohibitive rules. Thus, to exercise jurisdiction, a state need not predicate its action upon a permissive rule of international law. Rather, it is sufficient if there is no prohibition under international law. This principle, that states may act in absence of a prohibitive rule of international law, articulated by the Permanent Court, finds similar application to activities on the seabed of the ocean deeps.

International law imposes no prohibition upon the freedom of a state or its nationals exploring for and exploiting the resources of the seabed of the high seas provided this freedom is exercised with reasonable regard to the interests of other states in their exercise of high seas freedoms.5 In exercising this freedom by use of mobile surface facilities such as a drilling structure, the usual international law principles applicable to vessels would govern the relationship to the nation of the flag. Thus the structure or vessel would be subject to the exclusive jurisdiction of the flag state while on the high seas. And since there is no principle of international law prohibiting exploratory and exploitative activities on the seabed, interference by others would constitute a violation of international law vis-a-vis the flag state.6

The conclusion then is that mineral resources of the seabed under the high seas are subject to exploitation provided that there is no unjustifiable interference with other freedoms of the high seas including navigation, fishing and research.

- See U.N. Document A/AC.135/19 Add. 1, June 18, 1968, pp. 11-13.
- 2. Ibid., pp. 9-10.
- Louis Henkin, Law for the Seas Mineral Resources, (1967), pp. 35-36.
- 4. The S.S. "Lotus" (France v. Turkey), P.C.I.J., Sec. A, No. 10.
- 5. U.N. Document, op. cit., pp. 22 and 32.
- Wm. T. Burke, "Contemporary Legal Problems in Ocean Development," Towards a Better Use of the Oceans—A Study and Prognosis, (International Institute for Peace and Conflict Research, 1968), 66.

B. Policies for Optimum Mineral Development

Although existing international legal principles are sufficient to govern preliminary deep-ocean seabed activities, state regulation in matters of national jurisdiction and state consideration of long-term arrangements concerning the seabed should reflect policies which will encourage rather than deter the finding, recovery, and use of deep-ocean minerals.

Long experience has proven that economically successful mineral development laws, whether applicable to resources on land or under the seas, should have these policy objectives:

- To encourage, without discrimination, exploration for and production of resources at reasonable consumer cost consistent with a fair return to the investor.
- To encourage maximum efficient recovery by conservation both of minerals, and in the case of petroleum, of the natural forces, such as reservoir energy, which are required for production, always being mindful of the needs of future generations as well as our own.
- To reconcile competing uses of the environment and minimize adverse effects of mineral operations on that environment.⁷

In harmonizing competing uses in deep-ocean areas, each use should be considered upon its own merit and significance, and no particular use should be considered as having any per se value over another use.

While these policy objectives are requisite to successful mineral regulation, certain conditions must be established for the protection of the entrepreneur to induce his dedication of risk capital to the costly search. As ocean depth increases, the search for minerals becomes more risky and hazardous. Increasing amounts of capital are required and must be found in competition with other demands including mineral exploration onshore and in shallower waters.

Thus these four types of prerequisites should be operative to attract capital and talent:

- The regulatory arrangement should offer encouragement for mineral exploration with the promise of obtaining areas of sufficient size to justify later expenditures on concentrated exploration and development.
- Security of tenure is essential. The entrepreneur requires the exclusive right to occupy a defined area for exploration and the exclusive right to produce minerals discovered in that area for an assured period of time.
- 3. The mineral venture should be assured that in

- the event of exploratory success, the exactions of the granting authority, including royalties and taxation, will not be so oppressive as to discourage the enterprise or make its continuance uneconomic.8
- 4. The entrepreneur must be assured that the mineral regulatory system, including payments to the granting authority, will not be altered so as to be less favorable to it after investments have been made, i.e., the rules of the game should not be changed after the game has started.

The problem can thus be restated as follows: What arrangements will, on the one hand, best encourage mineral exploitation in seabed areas and also fairly balance governmental financial exactions with the risks of the enterprise, while, on the other hand, providing optimum benefit to consumers while remaining consistent with governmental objectives?

C. Recommendations

As suggested in previous chapters herein, it is believed that the greatest immediate interest in offshore petroleum activity will be in areas under the exclusive mineral jurisdiction of the coastal states. Thus the demarcation of the outer limits of rights of coastal states over continental margin areas should be of major current concern to the nations of the world. Still, it is appropriate at this point to appraise alternatives as to how exploratory or exploitative activity in deep-ocean areas should be legally structured, especially since this topic has occupied much attention in international circles.

- 1. It is recognized that there is an inadequacy of present knowledge concerning the natural resources and environment of the deepocean floor, and that much more information and data are necessary before more realistic suggestions as to arrangements which may eventually be required to promote optimum long-range development can be made. Therefore, the National Petroleum Council fully endorses the concept of the International Decade of Ocean Exploration, cooperative international research on the resources of the deep-ocean floor, and cooperative international study leading toward an eventual decision on the most appropriate and most effective arrangements for that vast area.
- On the basis of the exceedingly incomplete information that is now available concern-

8. Ibid., VII-VIII.

Report of the Committee on Deep Sea Mineral Resources in Proceedings and Committee Reports of the American Branch of the International Law Association, I, VII, (1967-68).

ing deep-ocean areas, it would be highly undesirable and indeed irresponsible for the United States to commit itself to any international regime to govern exploration and exploitation in these areas. Our Nation should, nevertheless, be prepared to provide leadership and cooperation to the international community looking toward optimum arrangements for development of deep-ocean mineral resources "for the benefit of and in the interest of all mankind."

3. Any early exploration of the deep-ocean floor could be carried out under the existing principles of international law with any conflicts that may arise being resolved on an ad hoc basis.

Although general rules of international law may not provide the necessary certainty for longrange mineral exploitation of the subsoil of the deep ocean, these rules will constitute the legal framework for any introductory activity that may occur for some years to come. Eventually it may be necessary to have more detailed international arrangements governing such operations, and cooperative studies providing the basis for the establishment of such long-term arrangements should be undertaken with all practicable speed,

Meanwhile, present consideration regarding legal arrangements for deep areas could be usefully directed towards formulating standards of conduct for individual nations and persons engaging in activity pursuant to national license.

Specifically, these standards should eliminate present uncertainty as to the accommodation of mining with other uses of deep-sea areas, and should include a means of establishing claims and their extent, and the conditions whereby they might be forfeited. Apart from defining the rights and duties of nations conducting any introductory deep-sea mineral exploration or exploitation, national acceptance of standards will also serve as useful guideposts for the future formulation of any long-term arrangements.

A step which might further international cooperation would be the establishment of an international registry, first to serve only as a record of exploratory activity, and later, after adoption of a code of conduct, to serve as a means of filing claim over minerals in a specified area. Initially at least, the procedure should provide for registration of claims, by nations only, with respect to those which may be licensed by them.

Agreed national standards of conduct including

work obligations would also serve to deny claims to nations not intending to move promptly to develop mineral resources within a specified area.

The establishment of such a registry and agreed standards of conduct could provide a measure of certainty about rights and interests which would encourage feasible mineral exploitation during the interim period.

4. Any agreement should also reaffirm that no nation has the right to acquire political sovereignty over areas of the deep-ocean floor and seabed.

The report of the U.N. Ad Hoc Committee on the Oceans to the General Assembly and expressions of view from many U.N.-member states reflect wide support for the position that states may not acquire territorial sovereignty over deepocean areas. Thus, any temporary occupancy necsary to the exploration for and production of mineral resources of the deep-ocean seabed should be defined and limited. And those who proceed to explore and exploit deep-ocean resources pursuant to national license should receive recognition of their interests whenever more long-term arrangements are agreed upon among concerned nations.

D. Conclusion

Significant interest and activity in deep-ocean petroleum resources beyond the area of coastal-state exclusive resource jurisdiction lie some years in the future. During the interim period, activities among nations to explore deep-ocean areas should be encouraged by such international cooperation as that conceived in the International Decade of Ocean Exploration. Nations should initiate with all practicable speed cooperative studies looking toward the establishment of long-term international arrangements mutually beneficial to all. Although it is essential that scientific, technical, exploratory and, where practicable, exploitative operations take place, the National Petroleum Council would support the necessary steps leading to formulation of national rules of conduct which would encourage orderly recovery of resources and discourage a resource race and resource grab in the deep-sea areas.

As expressed in the principles on page 77 and there is a common interest in promoting efficient and economic exploitation of the minerals of the seabed. Thus, any agreed arrangements should minimize unnecessary regulations that could deter exploitation, and should ensure that unrelated national differences not delay mineral recovery which will benefit all nations.

CHAPTER NINE—RELATIONS BETWEEN
THE PETROLEUM
INDUSTRY AND OTHER
USERS OF THE OCEANS
AND SEABEDS;
POLLUTION CONTROL,
CONSERVATION AND
RESEARCH

A. Relations with Other Users

As exploration, evaluation and exploitation of petroleum resources are extended further into areas under the high seas, some degree of conflict with the use by others of the high seas, the water column, and the underlying seabed is to be anticipated. Conceivable conflicting uses might include, (a) national defense, (b) navigation on the high seas, (c) communications, including undersea cables, (d) fishing, (e) hard minerals exploitation, (f) scientific research activities, (g) recreation, and (h) aesthetics.

Along the coasts of the United States, user conflicts have been, for the most part, avoided or minimized through the exercise of discretionary powers of state and federal authorities, and the cooperation of industry operators. The government agencies have broad powers to allow or prohibit mineral resource exploration activity and to lease only upon such conditions as are deemed appropriate following consultations with other concerned agencies.

The efforts of regulatory agencies have encouraged a greater degree of cooperation and flexibility among users, such as the use of better navigation equipment and notification procedures to reduce dangers of collisions and fouling of fishing gear. Gear conflicts with some fisheries have been minimized by dividing available time in particular areas. Seabed petroleum facilities have been designed to reduce the risks of fouling fishing gear, and some types of gear can be set to fish above known obstruction.

Problems of interference created by petroleum exploitation in the deep oceans beyond the continental margin can be expected to be fewer than those encountered in the shelf areas. This is because of the vastness of the oceans and the greater divergence of traffic and other potentially conflicting uses. It is anticipated that the interests of competing users of the deep oceans and seabeds, where not specifically covered by international law, will be cooperatively resolved to harmonize such interests. As a general principle, as restated from chapter 8, "in harmonizing competing uses in deep-ocean areas, each use should be considered upon its own merit and significance, and no particular use should be considered as having any per se value over another use."

A considerable, though not necessarily complete, body of international law already exists relevant to user interferences and settlement of disputes in the deep oceans. The 1958 Convention on the High Seas emphasizes freedom of navigation, fishing, and the laying of submarine cables and pipelines beneath the high seas. Many specific problems concerning navigation and identification of vessels engaged in various activities are resolved by the International Rules of the Road.1 Where operations are extensive, such as in the Gulf of Mexico which contains more than 2,200 fixed petroleum industry structures, cooperation between the government and commercial users has resulted in establishment of navigation fairways and anchorages, Freedom of navigation is thereby provided without unreasonable restraints on multiple user interests. Similar procedures might be employed for interferences in the deep sea, though interferences are likely to be remote.

In addition to the Convention on the High Seas, the 1884 Convention on the Protection of Submarine Cables establishes freedom to lay submarine cables and provides for their protection.² A U.N.-sponsored agency, the International Telecommunications Union, also affords a means of coordination and resolution of disputes between nations in communications across the oceans.

Multiple use problems between petroleum exploitation and commercial fishing interests could include physical interferences, such as those due to drilling or production structures, and the effect of any operations which would be harmful to fish life or the living resources of the sea on which they feed. Experience with the numerous petroleum industry structures in the Gulf of Mexico has demonstrated that their physical interference with fishing operations is limited because they occupy such a small portion of the total area. In fact, they appear to have enhanced fish catches, possibly resulting from additional food supplies which attach to the structures and the additional shelter afforded the fish population. ⁸

Some small loss of aquatic life, not significant overall, has resulted in past years from use of explosive charges in seismic exploration for oil and gas. Newer, nondynamite seismic energy sources developed by the petroleum industry have been shown in tests and observations to have no adverse effect on fish life. Since nondynamite seismic energy sources are now being used predominantly by the petroleum industry for seismic exploration in the oceans, such operations in the deep seas are not expected to interfere with commercial fishing through loss of aquatic life.

Simultaneous exploitation of the same area of the deep seabed for both petroleum and hard minerals might result in some interference by the very nature of the operations. This problem could be resolved by applying existing principles of international law and by formulating standards of conduct for individual nations and persons engaging in activity pursuant to national license, perhaps through an international registry system, as suggested in chapter 8.

The exploration and exploitation of resources should and can be carried out in a manner which would not unjustifiably interfere with scientific research that may be underway, following the principle that each use should be considered upon its own merit and significance and not as having a per se value over another use.

B. Pollution Control

Conservation of the natural environment and its resources is a matter of increasing significance both to national and international interests and, of course, conservation policies in areas under national and international law are interrelated.

Conservation and pollution control policies and measures to be applied in areas subject to coastal state sovereign rights for the exploration and ex-

^{1, 33} U.S.C.A. Secs. 1051-1053, 1061-1094 (1967 Supp.).

^{2.} March 14, 1884, 24 Stat. 989; 25 Stat. 1424; T. S. 380, 380-2, 380-3.

Starting in 1957, a major expansion of oil activity and installation
of structures offshore occurred in the Gulf of Mexico and in the
following 8 years the commercial fish catch in the Gulf of Mexico
doubled while the total catch for all other U.S. fishing areas declined. (Based on U.S. Department of Interior sources.)

ploitation of natural resources are and should remain a matter for regulation by such coastal states.

Accordingly, in the United States, the Federal and concerned state governments have promulgated regulatory systems designed to preserve the natural environment in these areas and to prevent and control pollution that might result from uses of the subsoil, water column, and surface of the territorial seas and the continental margin adjacent to its coasts.

Experience developed by the petroleum industry in exploring and exploiting hydrocarbons in various and diverse submarine areas will provide a continuing basis upon which to re-evaluate regulations designed to assure that these exploration and development activities will be conducted with a minimum of interference with other uses and with minimum danger to the surrounding natural environment and ecology. Recent events in the Santa Barbara Channel have highlighted coastal state and industry concern in this regard.

The body of international law which is devoted to control and abatement of marine pollution consists principally of the 1954 International Convention for the Prevention of Pollution of the Seas by Oil, as amended in 1962.4 This Convention generally prohibits the discharging of oil or oily wastes from ships within 100 miles from shorelines, and requires the logging in an oil record book of all oil transfer operations, such as ballasting, fueling, discharging of oily residues, and accidental discharges. It advocates the complete avoidance of discharge of persistent oils at sea and increased provision of facilities in ports and marine terminals for handling oil residues from ships. Even though international law allows oil dumping 100 miles or more from shore, most oil companies now maintain a strict policy against dumping of oil or oily ballast anywhere in the world's oceans. Under the Convention, research, national committees for review of prevention measures, and intergovernmental coordination of research and development leading toward improved abatement are encouraged. Administration of this Convention is under constant review by the Inter-Governmental Maritime Consultation Organization (IMCO), which has extended its studies to other polluting agents, such as chemicals and radioactive wastes.

IMCO studies indicate oil pollution at sea has originated primarily from ships. Discharges take various forms: oil tank washings from tankers, oily ballast waters from cargo ships, and oil from tanker accidents and from wrecks resulting from founderings or war actions.

In exploiting the deep-ocean seabeds for petroleum, the petroleum industry is cognizant of the great importance of preventing oil pollution. In addi-

tion, safety requirements and economic considerations by themselves dictate high standards of pollution control in the high-risk offshore environment. Very considerable research and development, sponsored by the U.S. petroleum industry, have been directed toward improving equipment reliability and pollution control techniques beyond the standards of national statutes or international law. Some of these include (1) the use of highly reliable blowout preventers during drilling operations and "storm chokes" during the producing life of wells, (2) installation of oil-water separation devices in drainage systems from platforms and oil ballast cleaning systems at marine terminals, (3) development and use of reliable methods of tracing oil pollution to its source via "finger printing," and (4) the use of "load-on-top" techniques for transport tankers.

Recent extensive research has been directed toward containing, dissipating or removing oil accidentally discharged at sea by methods which are not harmful to marine life.

Mindful of the continuing need to review appropriate safeguards against the dangers of pollution in the marine environment, the petroleum industry welcomes further cooperation with intergovernmental agencies engaged in studies to improve pollution abatement in the oceans.

C. Conservation

Good conservation practice may be defined as the wise and efficient use of natural resources and is an essential part of exploitation of petroleum resources. Petroleum conservation regulations and practices, while not directly dependent on water depth and distance from shore, nevertheless, must take account of the changes in economics and technology which occur as exploitation moves into greater water depths. Such regulations should recognize the importance of these factors as they affect recovery efficiency and be such as to encourage maximum efficient recovery both of the minerals themselves and, in the case of petroleum, the most effective use of the natural forces, such as reservoir energy, which are required for their production.

Operations out to the limits of the continental margin should be regulated by the various individual coastal nations. Ultimately, operations in the area of the deep-ocean floor would be subject to regulation as determined by international agreement for the exploitation of the resources on and under the deep-ocean floor. Such regulation should be exercised in accordance with the pertinent international treaties

May 12, 1954, 12 U.S.T. 2989; T.I.A.S. 4900. Amendment April 11, 1962, 17 U.S.T. 1523; T.I.A.S. 6109.

and conventions and in cooperation with appropriate international commissions and agencies.

D. Research

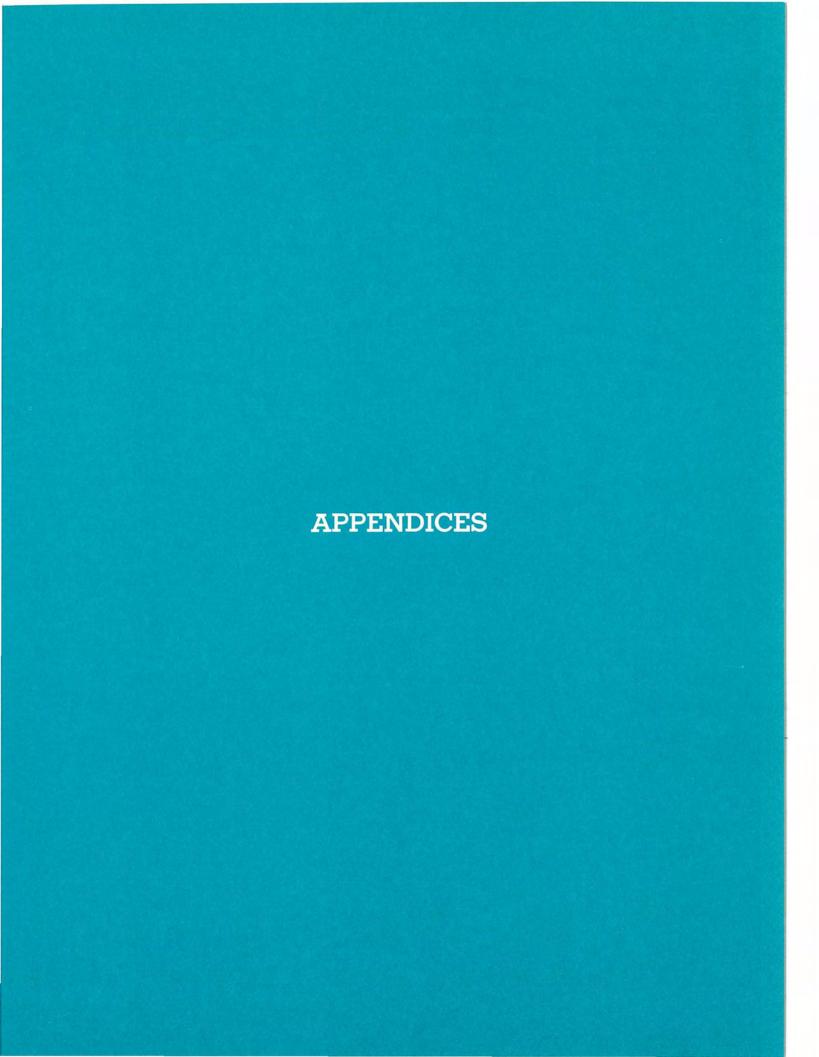
The conduct of any research concerning the continental shelf and undertaken thereon requires the consent of the coastal state under Article 5, paragraph 8 of the Geneva Convention on the Continental Shelf. This provision further states that "the coastal state shall normally not withhold its consent if the request is submitted by a qualified institution with a view to purely scientific research into the physical or biological characteristics of the continental shelf." If it so desires, the coastal state is entitled to participate in or be represented in the research and, in any event, the results shall be published.

Paragraph 1 of Article 5 of that Convention re-

quires that the exploration of the continental shelf and exploitation of its natural resources not interfere with fundamental oceanographic or other scientific research carried out with the intention of open publication.

The experience of petroleum exploration and producing activities clearly indicates that there is no incompatibility with research concerning the continental shelf or with fundamental or other scientific research. On the contrary, petroleum exploration has itself contributed greatly to the body of research and knowledge concerning the continental shelf.

Other types of research, unconcerned with the continental shelf or of a fundamental oceanographic or other scientific nature, are unaffected by the Convention on the Continental Shelf and would presumably be governed by general international law or any other applicable international agreement.



APPENDIX A

UNITED STATES DEPARTMENT OF THE INTERIOR OFFICE OF THE SECRETARY WASHINGTON, D. C. 20240

GOPY

January 24, 1968

Dear Mr. Donnell:

In the expanding search for new supplies of energy, it is clear that offshore areas are among petroleum's brightest frontiers, and in the next decade we should see unprecedented activity in this direction. Yet, as the search progresses into deeper waters it gives rise to political, legal, and economic implications of international import. Guidelines are quite limited; indeed, the only major guideline, apart from territorial waters, is that contained in the 1958 Geneva Convention on the Continental Shelf which in Article 2 provides that, for the purpose of exploration and exploitation of natural resources, the coastal state shall have sovereign rights over the Continental Shelf.

The Continental Shelf is defined in Article 1 as the seabed and subsoil of the marine areas adjacent to the coast but outside the area of the territorial sea "to a depth of 200 meters or, beyond that limit, to where the depth of the superjacent waters admits of exploitation of the natural resources of the said areas." Current and developing technology make the usefulness of this definition questionable.

There was a proposal before the last meeting of the United Nations General Assembly, put forward by Malta, embracing the concept that the ocean floor beyond the limit of present national jurisdiction should be reserved exclusively for peaceful purposes, and that jurisdiction over such areas and its resources should be administered by an international agency, with the financial benefit from their exploitation accruing primarily to the developing countries. This resulted in the establishment of an *ad hoc* committee to study questions relating to resources of the sea bottom and its report is to be submitted at the next session of the General Assembly.

In order to assist the Department of the Interior and other Government agencies in formulating their posture toward development of petroleum resources of the ocean floor, the National Petroleum Council is requested to prepare a study which should consider (a) whether the definition of the Continental Shelf is in keeping with technological advancements in offshore capability, (b) what type of regime would best assure the orderly development of the petroleum resources of the ocean floor and the time frame within which it might be implemented, (c) what type of regime is best designed to assure conservation of the resources and protection of the environment, and (d) any other points or comments deemed appropriate. We request the appointment of a committee for meetings to begin in February.

Sincerely yours,

/s/ J. CORDELL MOORE Assistant Secretary of the Interior

Mr. J. C. Donnell, II Chairman National Petroleum Council 1625 K Street, N.W. Washington, D. C. 20006

APPENDIX B

NATIONAL PETROLEUM COUNCIL COMMITTEE ON PETROLEUM RESOURCES UNDER THE OCEAN FLOOR

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Vaughey and Vaughey

SECRETARY

Vincent M. Brown Secretary-Treasurer

National Petroleum Council

APPENDIX C

TECHNICAL SUBCOMMITTEE OF THE NATIONAL PETROLEUM COUNCIL'S COMMITTEE ON PETROLEUM RESOURCES UNDER THE OCEAN FLOOR

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John E. Sherborne Associate Director of Research Exploration and Production Research Union Oil Company of California

C. H. Siebenhausen, Jr. Manager, Mechanical Engineering Shell Oil Company

Oliver L. Stone Associate General Counsel Shell Oil Company

APPENDIX D

FOR LIQUID HYDROCARBONS

(1970-2000)

- 1. Dometic production + imports = total U.S. supply.
- Total U.S. supply, + or inventory changes, = total U.S. demand.
- 3. Total U.S demand = domestic demand + export demand.
- 4. The concern is with the components of total U.S. supply.
- 5. Figure D-1 shows published estimates of U.S. domestic demand. The values (points) appear in table D-1.
- 6. U.S. domestic demand differs from total supply by the sum of exports and inventory change,
- Exports and inventory change should approximate 50-70 million barrels a year during the period 1980-2000. This is about ½ to 1 percent of total supply.
- 8. The Department of the Interior forecast of July 1968 is almost the same as their 1965 forecast.
- 9. The high, medium, and low RFF forecasts are the ones extending to year 2000 (high line goes off chart).1
- Department of the Interior estimates for 1970-1980 ranges about one-fifth to one-third of the way between the medium and high RFF forecasts.
- 11. Table D-4 shows the calculations of the new reserves requirements to meet the various RFF projections during 1981-2000, assuming:
 - a) imports = 20 percent of total supply, and
 - b) reserve/production ratio = 8 or 10: 1 at end of century.

^{1.} Landsberg, Fishman, and Fisher, Resources in America's Future, (1963), pp. 848-53.

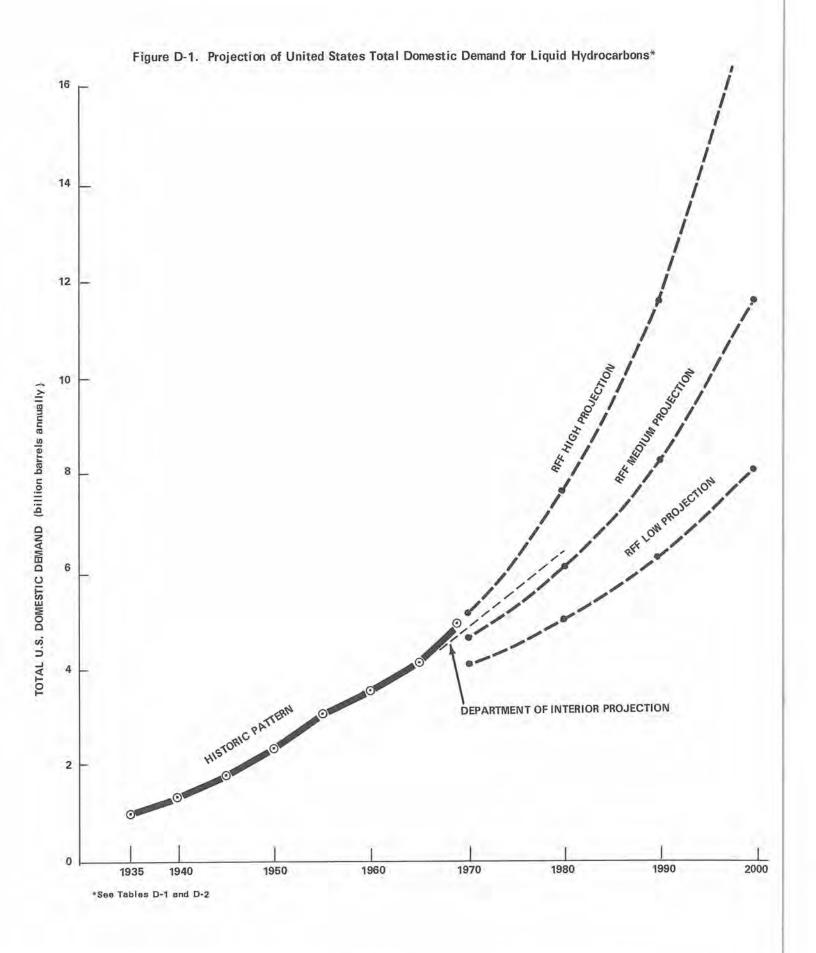


Table D-1. Forecasts of Domestic Demand Liquid Hydrocarbons (Billion Barrels Per Year)

	Resources in America's Future			Department of the Interior ^b	lines	Atlantic Richfield Company	Continental Oil Company a	Ion Union Co.	ices	First National City Bank	poration.	& npany	orporation	I Company	search Inst. SR1#312		Texas Eastern	Corporation
	Low Med.	High b	5 S S S S S S S S S S S S S S S S S S S	Bureau of Mines			Eastman Dillon Union Securities & Co.	6 Ebasco Services 9 Incorporated	(1961) First Nation	(1967) Gulf Oil Corporation	Humble Oil & 9 Refining Company	Mobil Oil Corporation	5) Standard Oil Company (9) (Indiana)	5 Stanford Research Inst. 2 SR1#226—SR1#312	Texaco Inc.	(1961)		
Ref. Year		1960		1963	1965	_		1965	1964	1966	1966	Ξ	_	1965		1966	1959	1965
Ref. Vol.		3.53		3.85	4.19	Œ	_	4.12	3.96	4.33	4,33	_	=	4.12	-	4.32	3.30	4.09
1970	4.07	4.62	5.25	4.89	-	=	_	-	-	4.80	4.94	-	_	-	4.75	-	4.63	4.85
1975	-	\Rightarrow	-	5.66	_	-	_	5.48	5,03	=	5,57	-	5.87	-	5.48	5.66	5.15	5.82
1980	5.03	6.09	7.66	6.42	6.66	6.20	6.39	_	=	_	6.24	_	_	6.20	6.34	_	5.72	6.93
1985	-	-	-	-	_	_	_	_	6.22	_	-	6.57	7.37		-	-		_
1990	6.31	8.21	11.62	-	-	-	-	-	=	=	=	_	÷.	-	\leftarrow	-	-	8.21
1995	-	-	=		=	=	_	=	=	=	=	-	2	100	<u>_</u> _ (=	_
2000	8.10	11.59	18.32	-	-	~	-			-	-	-	-	\Rightarrow	=	-	_	_

a Landsberg et al., op. cit.

Table D-2. Department of the Interior July 1968 Study* (Billion Barrels Annually)

	CRUDE OIL PRODUCTION	NGL PRODUCTION	TOTAL LIQUIDS PRODUCTION	IMPORTS	TOTAL LIQUIDS SUPPLY
1966	2.77	,59	3.36	.84	4.20
1967	2.87	.62	3.49	.87	4.36
1968	2.97	.65	3.62	.91	4.53
1969	3.07	.68	3.75	.94	4.69
1970	3.17	.71	3.88	.97	4.85
971	3.27	.74	4.01	1.00	5.01
972	3,37	.77	4.14	1.03	5.17
973	3.47	.80	4.27	1.07	5.34
974	3.57	.83	4.40	1.10	5;50
975	3.67	.86	4.53	1.13	5.66
976	3.76	.89	4.65	1.16	5.81
977	3.86	.92	4.78	1.20	5.98
978	3.96	.95	4.91	1.23	6.14
979	4.06	.98	5.04	1.26	6,30
980	4.16	1.01	5.18	1.29	6.46

(1966-1980)

52.00

12.00

64.00

16.00

80.00

^b See figure D-1 ^c Ira P. Cram

^{*}See figure D-1

Table D-3. Calculations of New Reserves Requirements to Meet Department of Interior Projections, 1965-1980 (Billion Barrels)

	OIL	NGL	LIQUIDS
Reserves @ 1/1/66	38.9	8,0	46.9
Additions Required — 15 Years	56.0	11,5	67.5
Production — 15 Years	52.0	12.0	64.0
Reserves @ 1/1/81	42.9	7.5	50.4
Reserve/Prod. Ratio 1965	14.4	13.7	14.2
Reserve/Prod. Ratio 1980	10.2	7.4	9.7

Table D-4. Calculations of New Reserves Requirements to Meet RFF Projections, 1981-2000 (Total Liquid Hydrocarbons) (Billion Barrels)

CASE	RESERVES @ 1/1/81	PRODUCTION 2000	RATIO OF RESERVES TO PRODUCTION @ 1/1/2001	RESERVES @ 1/1/2001	RESERVES 20 yrs.	PRODUCTION 20 yrs.	TOTAL NEW RESERVE REQUIRE- MENT 20 yrs.
RFF:							
Low	50	6.5	10	65	15	103	118
	50	6.5	8	52	2	103	105
Medium	50	9.3	10		43	136	179
	50	9.3	8	93 74	24	136	160
High	50	14.6	10	146	96	197	293
W. C. S. L. S.	50	14.6	8	117	67	197	264

COST INDICES

NOTE: The cost data presented in this appendix are rough approximations based on the limited amount of published data available at the time of writing this report. While isolated values may prove to be in error as more data becomes available, it is felt that the overall conclusions of this analysis as presented in the main text of the report will remain valid.

A. Exploration Drilling

Figure E-1 illustrates the variation of total daily drilling cost with water depth for the Gulf of Mexico. Mobile rigs are generally used for exploration purposes when dry hole risk is at a maximum. As shown in figure E-1, the daily drilling cost from mobile rigs in 600 feet (183 meters) of water is 80 percent greater than in 100 feet (30 meters) of water, and twice as great in 1,000 feet (305 meters) of water as in 100 feet of water. It is assumed that the cost of exploration drilling is directly proportional to these daily drilling costs.

It is currently thought that present floating drilling techniques can be extended to water depths of at least 1,500 feet (457 meters). Beyond 1,500 feet, several changes in the existing mobile drilling techniques will be necessary. Three of these changes are described below, and each of them will significantly increase the drilling cost trend.

1. Dynamic Positioning

With present marine conductor drilling systems the lateral movements of a floating drilling unit must be kept within 5 or 10 percent of the water depth to permit operations. Most units have eight or more 20,000-to 30,000-lb. anchors. These systems are heavy, costly, and cumbersome, and are not believed to be feasible in open ocean in water depths beyond about 1,000-1,500 feet (305-457 meters).²

For this reason, dynamic positioning systems have been developed and employed on coring vessels and several ship-shaped drilling vessels. These systems consist of a position indicator, an analog computer, and a propulsion system capable of producing thrusts of a variable direction and magnitude on command from the computer. There

are currently four large ship-shape drilling vessels under construction which will use dynamic positioning. The largest is the 50,000-ton *Noess Crusader*, whose computer and indicating system alone will cost in excess of \$1 million.³

Thus, the capital costs of dynamic positioning systems are high, and because an exploratory well can take 100 days to drill and evaluate, operating and maintenance costs could be significant. That dynamic positioning is costly is illustrated by the fact that at least three of the four drill vessels mentioned above will be equipped with conventional anchor systems for use in most drilling operations.⁴

2. Diver Capability

The deepest working dive on record was to a depth of 700 feet (213 meters) and consisted of a 15-minute biological survey.5 Laboratory dives have been made to depths slightly greater than 1,000 feet (305 meters),6 but it appears as if diver capability will be limited for the foreseeable future to less than 1,500 feet (457 meters). While drilling and completion systems have been developed to eliminate the need for divers, it has been found that even with these systems divers can be economically utilized to handle unexpected occurrences. The use of submersibles with attached manipulators in depths greater than the limits of diver capability will be costly.

3. Marine Conductor

The marine conductor extends from the wellhead, which is fixed on the ocean floor, to the floating drilling vessel. This conductor guides the drill pipe and bit down to the underwater wellhead and into the well

 [&]quot;Humble Gearing Up to Drill in 1300 Feet," Oil and Gas Journal, May 6, 1968.

[&]quot;Offshore Report," Oil and Gas Journal, July 10, 1967.

J. R. Dozier, "Offshore Oil and Gas Operations, Present and Future," Presented at Law of the Sea Institute, University of Rhode Island, June 1966.

^{3. &}quot;Where Dynamic Positioning Stands Now," Offshore, (May 1968).

^{4,} Ibid.

^{5.} Oil and Gas Journal, April 22, 1968.

^{6. &}quot;Men Under Pressure," Ocean Industry, (April 1968).

and provides a return path for the drilling fluid and cuttings. The guide function insures that as bits wear out and must be replaced the drill string will be able to reenter the hole; and the mud returns are desirable to decrease mud costs, aid in controlling the well, and also give an evaluation of drilling progress.

Because marine conductors designed to withstand wave and current forces in deep water are costly, they are not used in deep water, shallow depth core drilling programs. The core hole is drilled until the bit is worn out and the hole is then abandoned. A reentry drilling system without a marine conductor has not been developed.

As water depth increases, the cost of a marine conductor also will increase, until at some point a new system for drilling wells may have to be developed.

B. Development Drilling

1. Platforms

Generally, when a large field is discovered, a fixed platform is installed so that development wells can be drilled with a lower cost platform rig. The platform may also support some production facilities. The exploratory wells are either completed under water and produced to the platform, or they may be abandoned. Present platform technology indicates the industry can develop the capability to erect platforms in 600 feet (183 meters) of water,⁷ but beyond this depth, all development wells may have to be drilled with mobile units and completed on the ocean floor.

Figure E-2 shows platform costs can be expected to increase sharply as the water depth increases. The cost for existing platforms in the Gulf of Mexico vary from \$1.5 million in 100 feet (30 meters) of water to \$4 million in 350 feet (107 meters) of water. The cost of platforms in 600 feet (183 meters) of water is expected to approach \$12 million, or six to eight times as costly as those in 100 feet of water. The graph also indicates the effect of environmental conditions on platform costs, with platforms in Alaska's Cook Inlet costing about six times as much as Gulf of Mexico platforms for the same water depth.

There are locations, such as in the Santa Barbara Channel of California, where the

seabed has a steep slope and where, even though a development prospect may be in over 600 feet (183 meters) of water, it is possible to exploit it with directional drilling from a platform in 600 feet of water. Nineteen of the 71 leases purchased in the February 1968 Santa Barbara sale are in water depths too great to support a 600foot structure on the lease. These leases, which represent about 10 percent of the total bonus paid, lie entirely within 5 miles of the 600-foot contour, and a number of operators are undoubtedly planning on developing many of the tracts by directional drilling from platforms in 600 feet of water or less, or by completing wells under water and producing them to platforms in shallower water.8

2. Underwater Completions

Over 100 wells have been completed to date using underwater completion techniques. The techniques are well known, and the equipment has been proven. Because of the necessity of providing for well reentry to repair downhole equipment, remove paraffin, and to perform sand consolidation and various other remedial work, costs of underwater completions are very high.

In the Gulf of Mexico it costs about \$550,000 to drill and complete a 12,000-foot underwater exploratory well in 100 feet (30 meters) of water and to install a flow-line to a nearby platform. The cost for underwater wells should increase in proportion to the total daily drilling cost of mobile rigs (figure E-1) and should thus approach \$990,000 in 600 feet (183 meters) of water, and \$1,100,000 in 1,000 feet (305 meters) of water.

This can be compared to the \$400,000 cost of drilling and completing a platform well in 150 feet (46 meters) of water, including a share of platform costs. The cost of platform wells increases with water depth, as their share of the platform costs increase. From figure E-2, the per well share of platform cost is approximately \$80,000 in 100 feet (30 meters) of water, \$100,000 in 150 feet of water, and \$600,000 in 600 feet

^{7.} See footnote 1.

 [&]quot;Santa Barbara Channel—Promises and Problems," Ocean Industry, (May 1968).

M. E. Spaght, "The Development of Underwater Oil and Gas Reserves" Presented at Royal Swed. Acad. of Engrg. Sci., (1966).
 "Offshore Report," Oil and Gas Journal, June 20, 1966.

^{11.} Ibid.

(183 meters) of water. Thus the cost of a platform well can be estimated as \$400,000 in 100 feet of water and \$900,000 in 600 feet of water.

The latter figure is roughly equivalent to the cost of an underwater completion in this water depth. By projecting the curve of figure E-2, it appears that the initial costs of underwater development wells will be cheaper than platform wells in 1,000 feet (305 meters) of water. However, operating costs of underwater wells are relatively unknown at this time.

C. Production Facilities

After the wells are drilled, production facilities are required to permit processing, measuring, storing, and transporting the crude oil to a sale point.

Offshore platform-mounted production facilities do not differ significantly from those onshore. They are more expensive, however, because of the need to minimize weight and space, and the higher costs of offshore construction and operation. Also, in most cases living quarters and support facilities must be provided, which further increase costs. Within platform capabilities, the cost for facilities should not increase significantly as water depth increases. In water depths beyond platform capability, wells will be completed under water and produced to an underwater or floating production facility which can be expected to cost significantly more than platformmounted facilities.

Although several fields have been developed with underwater completions and flowlines from the individual wellheads to production facilities onshore, no underwater or floating production facilities have yet been installed. However, because of the demands placed on floating and underwater production equipment by the environment, as well as by the varied tasks which must be performed, it is clear that these facilities will be complex and costly.

In addition, because a diver or submersible vehicle is required for surveillance and maintenance, operating costs for underwater facilities will undoubtedly be much greater than those of existing surface facilities. Existing submersibles are mainly research vessels; they do not presently have manipulators capable of meeting the torque requirements of the offshore oil industry, and they are costly to build and operate.

D. Pipelines

Offshore pipelines in the Gulf of Mexico are between 2 and 41/2 times more costly than comparable

onshore pipelines.¹⁸ It is not possible to draw a graph of cost versus water depths from existing experience since costs depend also on location, size, weight and coating required, soil conditions, and wave and tide characteristics. For example, in Cook Inlet, Alaska, where 30-foot tides cause surface currents of 13 feet per second and bottom currents of 6 feet per second, and where severe weather conditions limit the laying season, the cost of an 8-inch line in 120 feet (37 meters) of water is approximately six times what it is in the Gulf of Mexico.¹⁴

1. Weather

The largest lay barges cannot operate in wave heights exceeding 10 to 15 feet and they experience difficulty transferring pipe in wave heights less than this. Thus, as operations expand into deeper, more exposed locations, delays due to weather will increase and costs will rise.

2. Location

As pipelines are laid in more remote locations and further from shore, mobilization and transportation expenses will increase. For example, a lay barge and its support equipment may cost \$20,000 per day in the Gulf of Mexico and \$60,000 per day in Cook Inlet.¹⁶

3. Method of Pipe Laying

In water depths of less than 100 feet (30 meters), most sizes of pipe are self-supporting and can be laid without the need of elaborate guides or tensioning systems to decrease the curvature. Stingers have been used in water depths of up to 300 feet (91 meters) to guide the pipe from the lay barge to the bottom. However, in this water depth a 700-foot stinger is required, which is costly and cumbersome, and operations are plagued with continued damage or trouble with the stinger.¹⁷

To eliminate the need for a long stinger, tensioning devices are used in conjunction with small stingers in water depths greater than 250 feet (76 meters) and up to 600 feet (183 meters). The tension required to maintain minimum curvature increases with size, and thus only small diameter pipelines

Resources of the Sea, Report of the Secretary General, United Nations Economic and Social Council, February 1968.

^{13. &}quot;Offshore Pipelining," Oil and Gas Journal, December 12, 1966.

^{14.} M. E. Spaght, loc. cit.

^{15. &}quot;Offshore Pipelining," loc. cit.

^{16.} Ibid.

^{17.} J. R. Dozier, loc. cit.

H. M. Wilkinson and J. P. Fraser, "Deep Water Pipeline," Paper (API Division of Production).

can be laid with this method in water depths from approximately 600 to 1,000 feet (183 to 305 meters). Beyond this depth new techniques will have to be employed. 20

4. Pipeline Burying

In deep water, wave action is not as strongly felt on the bottom, and in areas where currents are not a problem, pipelines will not have to be buried. Since most operators are currently burying pipelines in water depths less than 100 to 200 feet (30 to 61 meters), the elimination of the need to bury will partially offset the trends discussed above.²¹

19. "Offshore Pipelining," loc. cit.

 J. Delarvell, "The French Install Submarine Pipeline at Depth of 1080 Ft.," Oil and Gas Journal, August 7, 1967.

 R. Blumberg, "Hurricane Winds, Waves and Currents Test Marine Pipe Line Design," Pipe Line Industry, (June-November 1964), "Offshore Pipelining," loc. cit.

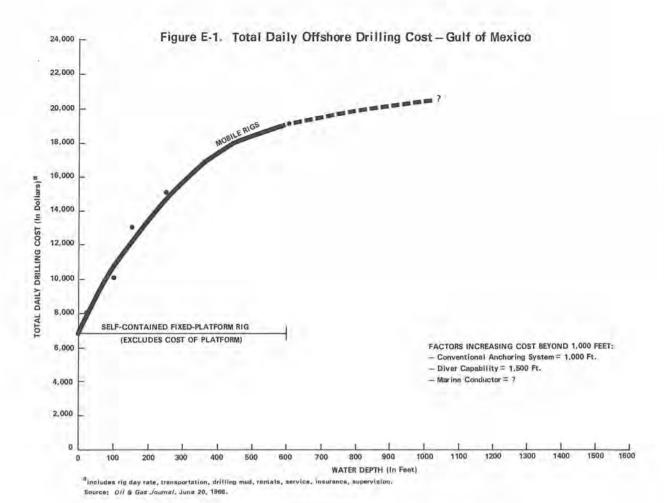
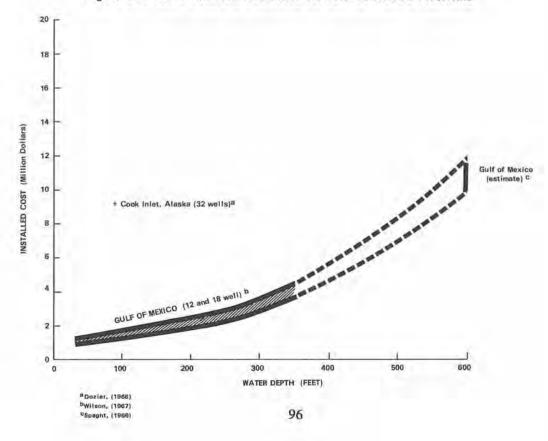


Figure E-2. Cost Data and Estimates for Self-Contained Platforms



COASTAL-STATE MINERAL JURISDICTION AND THE CONTINENTAL MARGIN

Survey of National Practice

To date, 102 nations,¹ including 98 coastal nations, have recognized the principle of the coastal-state's jurisdiction over adjacent offshore mineral resources. Thirty-nine nations (35 of them coastal) have asserted this principle by ratifying the Convention on the Continental Shelf.² The other countries have done so by one or more of the following methods: (1) by domestic legislation, (2) by agreement with other nations, or (3) by granting offshore concessions.³

Of the 98 coastal nations which have asserted their general jurisdiction over offshore minerals, at least 37 have done so with respect to specific submarine areas which, according to available information, appear to be beneath waters deeper than 200 meters. In most cases, this has been done by the issuance of deepwater leases; ** in others by decree, agreements with neighboring states or offers of such agreements, ** or announcements of national policy. **

A summary of this national practice appears below. Compilation of this information is complicated by (1) the variety of ways in which assertions of offshore seabed jurisdiction have been made, (2) apparent inconsistencies between law and practice in several nations, and (3) the fact that some nations have asserted seabed jurisdiction by more than one method. This summary is not limited to the practice of members of the United Nations.

- These 102 are identified in Parts I, II, and III of this appendix.
 To these 102 nations may be added five territories which are partially self-governing. See note 8 infra.
- 2. These 39 are identified in Part I of this appendix.
- These 63, plus five territories which are partially self-governing, are identified in Parts II and III of this appendix.
- 4. These 29 are identified in Part IV of this appendix.
- 5. Decrees or international agreements or tenders of international agreements have been found to include water deeper than 200 meters in instances which involve eight nations, in addition to the 29 nations which have issued deepwater leases. These eight are: Chile (200 miles); Dathomey (100 miles); East Germany (Baltic Sea Decree); Ecuador (200 miles); El Salvador (200 miles); Poland (Baltic Sea Decree); Saudi Arabia (Red Sea Decree); U.S.S.R. (Baltic Sea Decree). See also Soviet announcement in the United Nations of drilling in Caspian Sea at depths of 300 to 600 meters (U.N. Press Release GA/3929, 13 March 1969, p. 4).
- 6. For example, Canada.

ANNEXED LISTS

- Parties to Geneva Convention on the Continental Shelf (39).
- II. States, not parties to the Convention, which have made declarations or enacted legislation concerning jurisdiction over the continental shelf (49):
 - A. Adopted the Convention's definition (8)
 - B. Adopted the exploitability criterion (3)
 - C. Adopted other definitions (15)
 - D. Adopted shelf concept in general legislation or proclamation, but no precise definition (23)
- III. Other states and territories, not parties to the Convention, which have granted offshore concessions in apparent absence of general legislation (19).
- IV. States (whether or not parties to the Convention) which have granted offshore conces-

- sions for areas in which waters deeper than 200 meters have been provisionally identified (29).
- V. Practice of the United States.
- I. Parties to Geneva Convention on the Continental Shelf (39):7
 - 1. Albania
 - 2. Australia
 - 3. Bulgaria
 - 4. Byelorussian SSR
 - 5. Cambodia
 - 6. Colombia
 - 7. Czechoslovakia
 - 8. Denmark
 - 9. Dominican Republic

U.S. State Department, Treaties in Force, (Publication 8432)
 January 1, 1969.

- 10. Finland
- 11. France
- 12. Guatemala
- 13. Haiti
- 14. Israel
- 15. Jamaica
- 16. Madagascar
- 17. Malawi
- 18. Malaysia
- 19. Malta
- 20. Mexico
- 21. Netherlands
- 22. New Zealand
- 23. Poland
- 24. Portugal
- 25. Romania
- 26. Senegal
- 27. Sierra Leone
- 28. South Africa
- 29. Sweden
- 30. Switzerland
- 31. Thailand
- 32. Trinidad and Tobago
- 33. Uganda
- 34. Ukrainian SSR
- 35. USSR
- 36. United Kingdom
- 37. United States
- 38. Venezuela
- 39. Yugoslavia
- II. States, not parties to the Convention, which have made declarations or enacted legislation concerning jurisdiction over the continental shelf (49):
 - A. Adopted the Convention's Definition (8):
 - 1. Argentina: National Executive Power, Law No. 17,-094-M. 24 of 29 Dec. 1966 (U.N. Doc. A/AC. 135/11, p. 10).
 - 2. Germany: Federal Republic: Proclamation on the Continental Shelf, 20 Jan. 1964.
 - 3. Honduras: Congressional Decree No. 21 of the Constituent National Assembly, 19 Dec. 1957.
 - 4. India: Petroleum and Natural Gas Rules, 1959, Art. 3 (U.N. Doc. A/AC. 135/11/Add. 1, p. 13).

- 5. Italy: Act No. 613 of 21 July 1967, Law for Exploration and Production of Liquid and Gaseous Hydrocarbons in the Territorial Sea and Continental Shelf (U.N. Doc. A/AC. 135/11,
- p. 38). 6. Morocco: Petroleum Code, Dahir No. 1-58-227, 21 July

1958.

7. U.A.R.: Decree on the Conti-

nental Shelf, 3 Sept. 1958 (54 Am. J. Int'l

L. 497 [1960]).

- 8. Uruguay: Decree, 16 July 1963.
- B. Adopted the exploitability criterion (3):
 - 1. Brazil: Boletim Especial #196, 20 Oct. 1967, Embassy of Brazil.
 - 2. Norway: Provisional Act of 21 June 1963 relating to the Exploitation and Exploration of Submarine Natural Resources (U.N. Doc. A/AC. 135/11, p. 46).
 - 3. Philippines: Proclamation No. 370 of 20 Mar. 1968 (U.N. Doc. A/AC. 135/11, p. 47).
- C. Adopted other definitions (15):
 - 1. Canada: Statement of Canadian representative before U.N. Ad Hoc Committee on March 11, 1968 (U.N. Doc. A/AC. 135/1, p. 33), confirmed by Canadian Embassy, Washington, D.C. ("at least to the abyssal depths").
 - 2. Chile: Presidential Declaration Concerning the Continental Shelf, 23 June 1947 (U.N. Doc. A/AC. 135/11, p. 26); Declaration Over the Maritime Zone, Santiago, 1952, ratified by Decree 432, 23 Sept. 1954 (200 miles).
 - 3. Costa Rica: Article 1 of Decree-Law No. 803 of 2 Nov. 1949 and Article 6 of the Constitution ("sub-

- marine shelf and continental base").
- Dahomey: Decree No. 74 of 7 March 1968 (100 miles) (U.N. Doc. A/AC. 135/11/Add. 1, p. 11).
- Ecuador: Art. 630, Civil Code, 20
 Aug. 1960 (U.N. Doc. A/AC.
 135/11, p. 30) (200-meter isobath), but compare Declaration of
 Santiago, 1952, ratified by Executive Decree No. 275, 7 Feb. 1955
 (200 miles), and Supreme Decree
 No. 1542 of 10 Nov. 1966, amending Art. 633 of Civil Code (200 miles). (Inconsistency in article numbers appears in U.N. and
 P.A.U. documents).
- El Salvador: Arts. 1 and 8, Constitution of 1962 (200 miles).
- Germany: Democratic Republic: Declaration on the Continental Shelf of the Baltic Sea, Moscow, October 23, 1968 ("the surface and subsoil of the bed of the Baltic Sea as a shallow sea are a continuous continental shelf").
- Ghana: Act No. 175, The Territorial Waters and Continental Shelf Act, 19 April 1963 (U.N. Doc. A/AC. 135/11, p. 34) (100 fathoms).
- Indonesia: Government Regulations substituting Law No. 44 of 26 Oct. 1960 on the Mining of Petroleum and Natural Gas (Continental Shelf of the Indonesia Archipelago).
- Ivory Coast: Offshore Law, Decree 67-334 of 1 August 1967 (200 meters).
- 11. Nicaragua: Declaration in May 1949 under Constitution of 1948 (200 meters). Executive Decree of 5 April 1965 (200 miles) appears to apply only to living resources. The Constitution of 1 Nov. 1950 states that the National Territory includes the "continental shelf" and "submerged foundation."
- 12. Panama: Law No. 31 of 2 Feb. 1967 (200 miles).

- Pakistan: U.N. Legis. Series ST/ LEG/SER. B/6, Dec. 1956, at 38 (100 fathoms adopted in 1950).
- Peru: Presidential Decree No. 781 of 1 Aug. 1947 (200 miles); Petroleum Law No. 11780 of 12 March 1952 (200 miles).
- South Korea: Presidential Proclamation of Sovereignty Over Adjacent Seas, 18 Jan. 1952 (Continental Shelf regardless of depth of water).
- D. Adopted shelf concept in general legislation or proclamation, but no precise definition (23):
 - Bahamas (U. K.): Bahamas (Alteration of Boundaries) Order in Council No. 2574, 26 Nov. 1948.
 - British Honduras (U. K.): Oil Mining Regulations, 2 Sept. 1949.
 - Brunei: The Petroleum Mining Enactment, 1963.
 - 4. Burma: Concession Rules, 1962.
 - Greece: Petroleum Law (Law 3948) of 10 April 1959.
 - 6. Iran: Law of 19 June 1955.
 - Iraq: Proclamation of 24 Nov. 1957 (U.N. Doc. A/AC. 135/11, p. 36).
 - Jamaica: Jamaica (Alteration of Boundaries) Order in Council (No. 2575) of 26 Nov. 1948.
 - Kuwait: Proclamation of 12 June 1949 (U.N. Doc. A/AC. 135/11, p. 39).
 - 10. Libya: Petroleum Law of 1955.
 - 11. Nigeria: Mineral Oil (Amendment) of 17 Dec. 1959.
 - Saudi Arabia: Royal Pronouncement of 28 May 1949; Regulations for the Ownership of Red Sea Resources, Royal Decree No. M/27 of 1 October 1968.
 - Spain: Hydrocarbons Act of 26 Dec. 1958.
 - Persian Gulf States:
 - Bahrain: Proclamation of 5 June 1949.
 - 15. Muscat & Oman: Offshore activ-

- ity, Petroleum Press Service, June 1968 at 204.
- 16. Qatar: Proclamation of 8 June 1949.

Trucial States:

- 17. Abu Dhabi: Proclamation of 10 June 1949.
- 18. Ajman: Proclamation of 20 June 1949.
- 19. Dubai: Proclamation of 14 June 1949.
- 20. Fujairah: Offshore activity, Petroleum Press Service, July 1966 at
- 21. Ras al Khaimah: Proclamation of 17 June 1949.
- 22. Sharjah: Proclamation of 16 June 1949.
- 23. Umm al Qaywayn: Proclamation of 20 June 1949.
- III. Other states and territories, not parties to the Convention, which have granted offshore concessions in apparent absence of general legislation: (Data from announcements and press reports.)8
 - 1. Angola (Portugal): Boletim Oficial Sept. 12, 1964. See also Petroleum Press Service, June 1968 at 204. (The jurisdiction of Portugal outside of its territorial seas is set forth in Law 2080 of March 21, 1956. This law applies to all overseas territories of Portugal. Basis II limits concessions to the 200-meter isobath, except "when a special law otherwise disposes.")
 - 2. Cameroon: Petroleum Press Service, June 1968 at 204.
 - 3. Cuba: Concession map of October 1957, reproduced in Barrows, Petroleum Legislation. Presumably expropriated.
 - 4. Equatorial Guinea (Fernando Poo, Rio Muni): See Decreto 1043/1968 of 2 May 1968 re: Rio Muni (published 27 May 1968); Petroleum Press Service, June 1968, p. 204.
 - 5. Ethiopia: Several offshore concessions are in effect.
 - 6. Gabon: Decree No. 375 of July 5, 1968.
 - 7. Guyana: Two offshore concessions are in effect.

- 8. Japan: Petroleum Press Service, August 1968 at 305. Two offshore concessions are in effect.
- 9. Mauritania: Two concessions are in effect; "Oil & Gas Discoveries," February 1968, pp. 33-34.
- 10. Mozambique (Portugal): Petroleum Press Service, Nov. 1967, p. 420. See Diario do Governo 11 Oct. 1967, "Bases Anexas ao Decreto," No. 47,990.
- 11. Somalia: Concession granted 29 May 1961.
- 12. Spanish Sahara (Spain): Petroleum Press Service, Nov. 1966, p. 427.
- 13. Sudan: Exploration licenses have been granted for deepwater metal-containing brines in the Red Sea.
- 14. Surinam (Netherlands): Petroleum Press Service, July 1966, p. 275.
- 15. Timor (Portugal): Petroleum Press Service, June 1968, p. 204.
- 16. Togo: Petroleum Press Service, June 1968 at 204.
- 17. Tunisia: Petroleum Press Service, Jan. 1967 at 33.
- 18. Turkey: Three offshore concessions were in effect in 1966.
- 19. Yemen: One offshore concession was granted in 1961.
- IV. States (whether or not parties to the Convention) which have granted offshore concessions for areas in which waters deeper than 200 meters have been provisionally identified; 9

Note: This listing is based on an examination of concession agreements, concession maps, decrees and other data believed to be reliable.

- 1. Australia
- 10. Guyana
- 2. British Honduras *
- 11. Honduras *
- Canada
- Indonesia *
- Cuba (concession)
- 13. Italy
- outstanding in 1957) 14. Jamaica *
- 5. Denmark *
- 15. Japan
- Equatorial Guinea
- Malaysia Mauritania *
- 7. Ethiopia *
- 8. Gabon
- 18. Norway
- 9. Ghana
- 19. Oman

^{8.} Of the 19 jurisdictions listed here, five are territories (Angola, Mozambique, Spanish Sahara, Surinam and Timor).

^{9.} In countries marked with an asterisk (*), the seaward boundary of concessions examined appears to approximate the 100-fathom isobath, but lies beyond that isobath in one or more areas.

20.	Panama *	25.	Sudan
21.	Peru *	26.	Surinam
22.	Philippines *	27.	Trinidad
23.	Senegal	28.	Turkey
24.	Spanish Sahara	29.	U.S.A.

On March 13, 1969, the U.S.S.R. representative stated in the U.N. Committee on the Peaceful Uses of the Seabed Beyond the Limits of National Jurisdiction that, "In the Soviet Union drilling was being carried out in the Caspian Sea at depths of from 300 to 600 metres. . . ." 10

V. Practice of the United States

In 1961, the Department of the Interior granted a phosphorite lease off the California coast in water depths ranging from 240 to 4,000 feet (73 to 1,340 meters). This lease was subsequently surrendered.¹¹

In 1963 and 1964, the Department issued oil and gas leases in water depths ranging up to 1,500 feet (457 meters). In 1968, oil and gas leases issued in Santa Barbara Channel included an area in 1,800 feet of water (550 meters).

In 1968, a U.S. oil company drilled a well in 1,299 feet of water (395 meters), penetrating rock to a depth of 13,622 feet. This well was plugged and abandoned.

The Department has published leasing maps for areas off the California coast as far as 100 miles from the mainland, at depths as great as 6,000 feet (1,828 meters).¹⁸

In 1967, the Department granted a permit to Humble Oil & Refining Company to drill 21 coreholes beneath the Atlantic Ocean in water ranging in depth from 650 feet to 5,000 feet (198 to 1,523 meters) on "the continental slope beyond the continental shelf off Florida and northward to points seaward of Cape Cod and Georges Bank." The areas in which drilling was authorized lie as far as 300 miles from the coast. The permit was not exclusive, and does not include rights to any mineral leases. 14

The United States has asserted jurisdiction over resource development on the Cortez Bank about 100 miles from the California mainland, separated from the mainland by a trench about 1,500 meters deep.¹⁵

^{10.} U.N. Press Release GA/3929, 13 March 1969, p. 4.

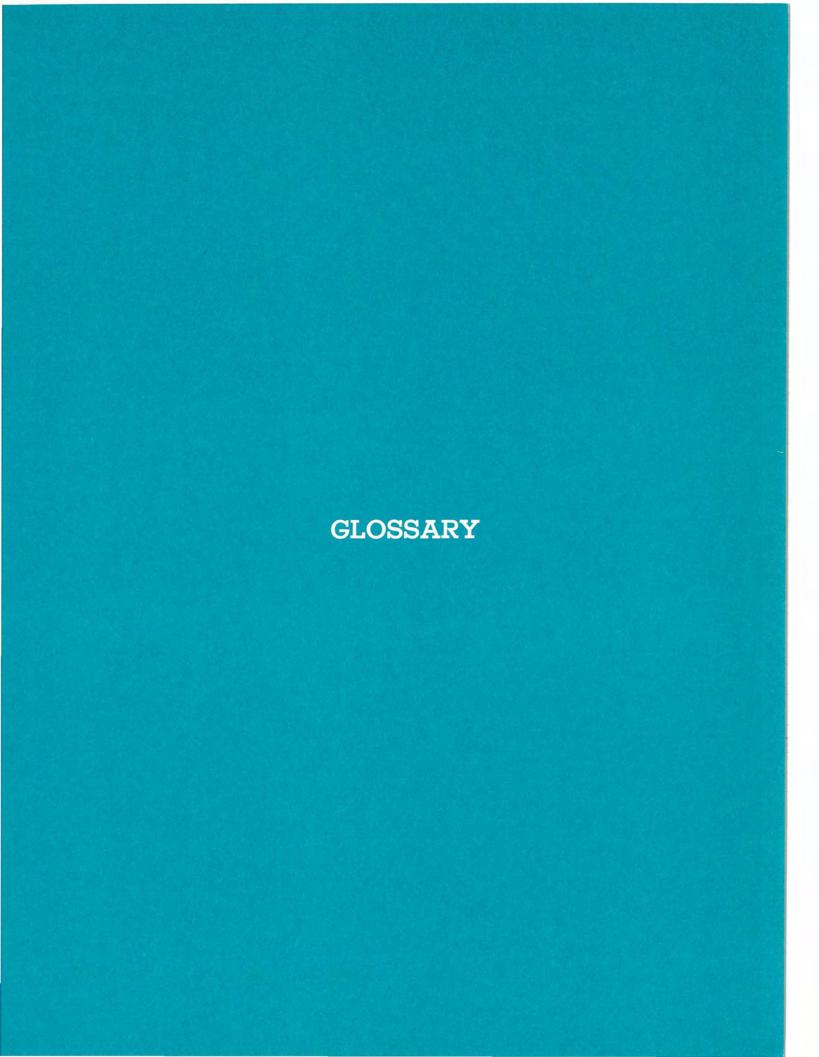
^{11.} Interim Report on the United Nations and the Issue of Deep Ocean Resources, by the Subcommittee on International Organizations and Movements of the House Committee on Foreign Affairs, H.R. Rep. No. 999, 90th Cong., 1st Sess. (1967) at 151. The memorandum opinion of the Associate Solicitor, Department of the Interior, dated May 5, 1961, concerning the application of the Outer Continental Shelf Lands Act to the lease area, is printed in the Interim Report, pp. 165-68.

^{12.} Ibid, p. 164.

F. Barry, "The Administration of the Outer Continental Shelf Lands Act," Natural Resources Lawyer, vol. 1, July 1968, pp. 38, 47.

Geological Survey Release, "Core Drilling to Begin on Continental Slope Off Atlantic Coast," No. 94, 229-67, May 26, 1967.

^{15.} Barry, op. cit.



(Geomorphic and Geologic Terms)

It appears desirable to indicate the sense in which certain terms, principally with reference to the ocean-covered portions of the earth, are used in this report, since many of these terms have somewhat variable usage in the current literature. Without in any way meaning to suggest that our usage is "correct," or preferable to that of others, we give the following definitions (usually over-simplified) of terms as we are using them in this report. Some of the terms are geomorphic—that is, pertaining to surface form only; others are geologic—that is, involving the nature of the rocks themselves; still others are both. A few particularly helpful literature references are appended.

Abyssal Ocean Floor-The deep-ocean floor seaward from the continental slope and the continental rise.

Abyssal Plains—The nearly flat areas which occupy the deepest portions of many ocean basins.

Coastal Plain—A plain of low elevation above sea level and gentle seaward inclination, bordering the seacoast and commonly representing an emergent extension of the continental shelf.

Continental Block ("Continental Mass")—These terms have a combined geomorphic and geologic connotation and refer to the relatively high-standing sialic mass which forms the combined emergent and submerged portions of the continent.

Continental Borderland—A zone of irregular ocean-bottom topography on the submerged continent corresponding in position to the continental shelf but with depths, at least locally, much greater than those of the normal shelf. For example, the Southern California Borderland is "a checkerboard of basins, banks, and islands with a regional physiographic trend similar to that of the adjoining land area," all of which lies within the bounds of the continental crust.

Continental Crust—The portion of the earth's crust generally underlying the continents. It is characteristically of sialic (relatively high silica and alumina content) composition, and of lesser density, lower seismic velocity, and greater thickness than the crust under the oceans. It tends to stand higher in surface elevation than the oceanic crust because of its lower density. It is also commonly known as "granitic crust."

Continental Margin—This term is currently used with several different meanings. In a geomorphic sense it is generally used to indicate a zone separating the emergent continents from the deep-sea bottom; and as such generally includes the continental shelf, continental slope and continental rise (Heezen et al., 1959). However, Guilcher (1963) and others have used the term "margin," in a geomorphic sense, to include only the shelf and the slope. The U.S. Geological Survey has used the term in a geologic or 3-dimensional sense to indicate the submerged part of the continental block.

Because of this diversity in usage we have chosen to use the term "continental margin" with a rather broad vernacular meaning, to indicate a geomorphic/geologic zone of rather indefinite extent at the edge of the continental block encompassing the transition from continent to ocean basin. Geomorphically, it would usually include the shelf, slope, and that landward portion of the rise which overlies continental crust. Geologically, it would include the transition zone from oceanic to continental crust. Where a more exact meaning is needed, we have used more specific terms such as continental slope, continental shelf, and continental rise.

Continental Rise—A geomorphic term for the apron of sediments which slopes very gently oceanward from the base of the continental slope. The contact between the slope and the rise is usually marked by a change in bottom gradient from more than 1:40 for the slope to less than 1:1,000 for the rise. Water depths on the rise commonly range from 1,500 to 5,000 meters. The width of the rise may be as great as 1,000 km. The oceanward edge of the rise merges with the abyssal plains. The landward portion of the continental rise commonly overlaps the submerged edge of the continental block. Continental rises are not everywhere present at the borders of the continents. They are particularly well developed adjacent to large deltas and may comprise thicknesses of 1 to 10 km. of sediments.

Continental Shelf—A geomorphic term for the usually gently seaward-sloping submerged plain bordering the continents and extending seaward from the shoreline to a point where there is an abrupt descent toward the deep-ocean floor. The width of the shelves of the world ranges from less than 1 km. to as much as 1,200 km. The depth at the outer edge varies from 50 to 550 meters. The average inclination of the shelf is generally less than 1:600 (figure 3A, chapter 3).

- "Legal Continental Shelf"—This term is used to indicate the definition of the continental shelf given in the 1958 Geneva Convention on the Continental Shelf—which is not the geomorphic continental shelf defined above. In our report, the expression "continental shelf" is used for the geomorphic continental shelf. When reference is made to the continental shelf of the Geneva Convention the term "legal continental shelf" is always used (see Introduction, footnote 4, p. 2, for exact wording of the definition given in the 1958 Geneva Convention on the Continental Shelf).
- Continental Slope—A geomorphic term for the frontal edge of the continental shelf. The continental slope is the relatively steep portion of the ocean floor extending from the rim of the continental shelf down to the deep-ocean floor. The width of the slope is generally about 15 to 50 km. and its water depth usually ranges from 50-550 meters at its upper edge to 1,500-5,000 meters at its lower edge. Its slope is commonly about 2°-6° (average gradient about 1:14) but locally may be 20°-30° or even more. The slope is frequently flanked on its seaward side by the continental rise which may meet the slope at depths of 1,200-5,000 meters. On the other hand, where the slope is bordered by a trench, as along part of the western coast of South America, it may extend to depths of as much as 8,000 meters. Although the continental slope is a geomorphic feature, the foot of the slope roughly coincides with the change from continental to oceanic crust (figure 3A, chapter 3).
- Continental Terrace—A geomorphic term used to express the combined continental shelf and continental slope.
- Continents—The great, relatively high-standing areas of the earth's surface, largely emergent above sea level with a portion overlapped by the oceans at their borders. The continents are generally underlain by "continental crust." The term "continental platform" is sometimes used in essentially this same sense to include the emergent continent plus its submerged shelf and slope.
- Great Ocean Basins—The major depressions of the earth's surface lying out beyond the continental slope and generally underlain exclusively by "oceanic crust."
- Island Arcs—Arcuate chains of islands usually convex toward the oceans, characteristically lying just off the borders of the continents but rising usually from the oceanic crust.
- Ocean—The vast salt-water body which covers the bulk of the earth's surface and overlaps the edges of the continents. As a matter of geography, this body of water is divided into subsections, themselves labelled oceans, e.g., Atlantic, Pacific, etc.
- Ocean Basins—The deep and extensive depressions of the earth's surface, occupied by the ocean and contrasting with the continents. The ocean basins are generally underlain by "oceanic crust."
- Oceanic Crust—The portion of the earth's crust generally underlying the oceans. It is characteristically of mafic (relatively high magnesium and iron content) composition, and of greater density, higher seismic velocity, and lesser thickness than the crust under the continents. It tends to be depressed in elevation relative to the continental crust because of its higher density. It is also known commonly as "basaltic crust."
- Oceanic Ridges and Rises—Relatively elevated areas of the mid-ocean floor distinct from features of the continental margin. The Mid-Atlantic Ridge is a prominent example and is a mountain-like median arch on the Atlantic Ocean floor roughly paralleling the continents on either side.
- Oceanic Trenches—Deep, ocean-bottom troughs frequently flanking the continental margins. The continental slope may continue down into these trenches, as off the coast of Peru and Chile. In some regions the oceanic trenches appear to have been filled with sediments so that they are now replaced geomorphically by continental rises.
- Semienclosed Sea—Along the margins of the continents, and occupying basins more or less separated from the main ocean basins, are a large number of relatively small, often semienclosed or nearly landlocked bodies of marine waters which in this report are referred to as "semienclosed seas." They have been called "marginal seas" by some authors. Maximum water depths in these seas may range from less than 200 meters to many thousands of meters. Some of the basins occupied by these seas are closely related geologically to the adjacent continents; others are underlain by oceanic crust; still others have crustal sections transitional between oceanic and continental. The semienclosed sea basins are essentially the "small ocean basins" of Menard. In contrast to the major deep-ocean basins, many of the semienclosed sea basins have thick sedimentary sections, even beneath their abyssal floors. There are some 40-50 of these seas. Examples are: the Gulf of Mexico, Adriatic Sea, North Sea, Andaman Sea, Sea of Okhotsk, Mediterranean Sea, Black Sea, etc.
- Submerged Continent ("Submerged Continental Mass")—These terms apply to the portion of the continental block which is beneath the oceans.

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