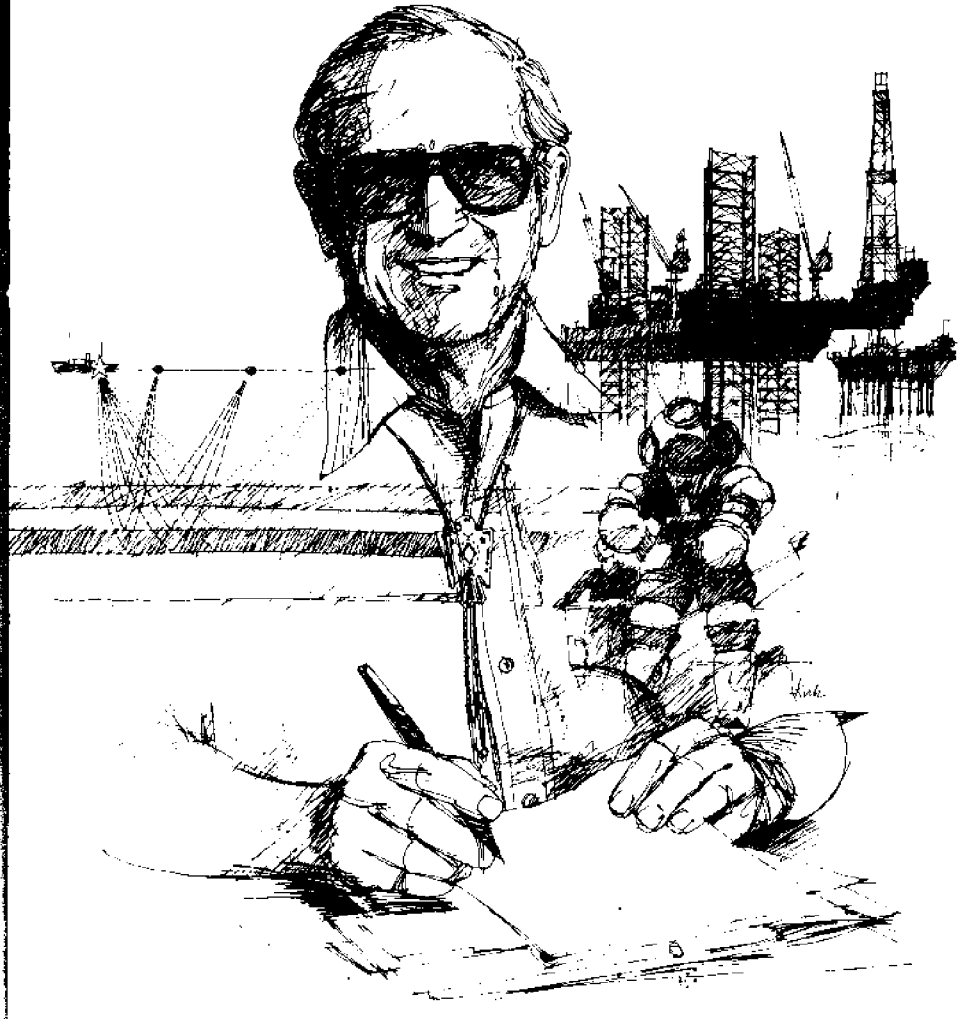
the McKERNAN lectures

Balancing Unknowns

a decade of controversy
about developing the outer continental shelf

H. William Menard



Donald L. McKernan Lectures in Marine Affairs

Balancing Unknowns

a decade of controversy about developing the outer continental shelf

H. William Menard

October 27–29, 1981

A Washington Sea Grant Publication
in cooperation with the Institute of Marine Studies
College of Ocean & Fishery Sciences—University of Washington
Seattle 98195

This publication is supported by grant number NA81AA-D-00030, projects E/MS-7 and A/PC-5(b), from the National Oceanic and Atmospheric Administration to the Washington Sea Grant Program.

WSG 82-2

Keywords: Offshore oil exploration and development, outer continental shelf, oil leasing, U.S. Geological Survey, lectures.

Contents

the McKERNAN lectures

This lecture series honors Donald L. McKernan, first Director of the Institute for Marine Studies at the University of Washington, and a distinguished fishery scientist, public servant, and diplomat. In May, 1979, while on an official visit to Beijing, he died of a heart attack.

His friends at the Institute decided that an annual lecture series would be a most appropriate memorial. We found sympathy in the Washington Sea Grant Program and its former director, Dr. Stanley Murphy, who agreed to provide the necessary funds. An institute committee, chaired by Professor Edward Miles then selected lecturers. Previous speakers have included Peter Larkin, dean of graduate studies at the University of British Columbia; Joseph Nye, professor at the Kennedy School of Government, Harvard University; and Roy Jackson, formerly deputy director general of the United Nations Food and Agriculture Organizaton.

Although Don McKernan specialized in fisheries, he was early to recognize offshore oil and gas as a rival for the position of most important oceanic resource. A decade ago, fisheries people seemed somewhat annoyed at the pretensions of this "upstart," but subsequent events have placed it high on the marine policy agenda.

Professor H. William Menard of the Scripps Institution of Oceanography is uniquely qualified to discuss the potential benefits and the probable costs of offshore development. His most recent position—that of director of the U.S. Geological Survey during the Carter administration—gave him a national responsibility for dealing with the issue. But for years before he went to Washington, D.C., he was an active investigator of marine geology and especially of the geology of the Pacific Basin. His contributions in this role were eventually recognized by his election to the National Academy of Sciences.

I first knew Bill Menard some thirty years ago when, after completing his doctorate at Harvard, he came to San Diego to the then Navy Electronics Laboratory and began his work of mapping and interpreting the characteristics of the sea bed. We sailed together on the Northern Holiday Expedition in 1951, during which we traced the Mendocino Escarpment offshore for some thousand miles. In 1955, Bill was appointed to the Scripps faculty, where he has been ever since except for an occasional year on sabbatical (including the one at the Office of Science and Technology in Washington) and his recent four-year tour with the Geological Survey.

During the pre-USGS days when I knew him best, Bill went to sea, did a lot of scientific diving and wrote innumerable scisentific papers and an occasional book (including one on the sociology of science and another entitled *Anatomy of an Expedition*). As many in the academic community are called upon to do, he served on various national advisory committees: one of these had to do with evaluating the consequences of the Santa Barbara oil spill.

None of us needs to be reminded of the extent to which our nation's future is dominated by the control of energy resources in foreign hands. If significant quantities of oil and gas are found on our continental shelf, energy independence is likely. Yet, the costs of recovering these resources are likely to be high—especially when environmental impacts are taken into account.

What balance is there between the prospects and the potential costs? Bill Menard is in as good a position as anyone in the world to define that balance for us. During his recent years in government service, he may not have been able to speak freely on this question: in these lectures he should be able to do so.

Warren Wooster
October 27, 1981

The McKernan Lectures

Pacific Salmon
Scenarios for the Future
By Peter Larkin

Should We Cut Our LOSes?
U.S. Foreign Policy and International Regimes
By Joseph S. Nye

Extended National Fisheries Jurisdiction
Palliative or Panacea?
By Roy I. Jackson

Balancing Unknowns:
A Decade of Controversy
About Developing the Outer Continental Shelf
By H. William Menard

These publications may be ordered from Washington Sea Grant Communications,
University of Washington, Seattle, WA 98195.
Price: $3.00 (includes handling and postal fees).
Washington residents, please add applicable sales tax.

Balancing Unknowns

a decade of controversy
about developing the outer continental shelf

Past and Present

As a native of Los Angeles I was brought up in a city with pumping oil wells, a countryside with large oil fields, and a shoreline interrupted here and there by piers with oil derricks. I don't recall that anyone thought much about it. We had tar on the beaches but everyone knew that there had always been tar on the beaches, and people were tolerant. Why is the attitude of so many people, including myself, now so different? In this brief introduction I shall attempt to give some historical perspective to the change.

Consider Southern California in the 1920s, and the costs and benefits of producing oil. The intense environmental costs of developing and producing oil were quite local, and happily borne by the local landowners because they reaped the benefits of royalties. They could afford to move elsewhere. As to the less fortunate, public lands were uncrowded, private land was extensive and cheap, and hardly anyone had any reason to be troubled by an oil field. Indeed the benefits were shared in the form of low-cost energy. Solar heating, now largely a dream for the future, was widespread at one time under the clear, sunny skies of Los Angeles. It was displaced by cheap natural gas.

The development of oil and gas on the continental shelf was not very significant in the following decades. Oil was generally in surplus from fields on land, and no reason existed to develop expensive technology to drill offshore. Meanwhile, however, the growth of population and industry began to crowd the empty land and conflicting interests battled for the undeveloped plots. Likewise the skies and water became perceptibly polluted and, once again, conflicting interests appeared.

In the 1950s and 1960s the environmental movement matured and Rachel Carson's *Silent Spring* led ultimately to the National Environmental Policy Act, Clean Air Act, and the Coastal Zone Management Act. Congress mandated that any action that might have a significant effect on the environment was forbidden until the effects could be scientifically assessed, the effects of possible alternative actions could be evaluated, and the whole was subjected to an elaborate sequence of public hearings. These assessments became known as "environmental impact statements," or simply as "e.i.s.'s." The e.i.s. was quickly expanded to include the social and economic effects that might occur in communities near the site of a major action. It soon became painfully apparent that the courts, federal, state and local agencies, industry, environmentalists, scientists and the public were incapable of carrying out the requirements of the new laws. With the best good will, no one could be sure about the relative importance of various environmental factors. A whole new industry developed employing archeologists, entomologists, marine biologists, geologists and so on to make detailed field studies—for what purpose no one was sure. The evaluation of alternative actions became ever more sophisticated while the facts and predictions on which they were based were as fanciful as at the beginning. Environmental impact statements became as lengthy as encyclopedias—although by no means as easy to read nor as long retained.

Action moved from the construction site or drilling platform to the courts, and the legitimate and initially partially compatible objectives of "industry" and "environmentalists" became increasingly polarized. With regard to continental shelf development, the late 1960s witnessed a remarkable series of significant oil spills just in the places where they would be most vocally resented and most convenient for media exposure. The Santa Barbara oil spill from a drilling platform and the Torrey Canyon and Amoco Cadiz shipwrecks off England and France aroused world-wide concern and hardened resistance to further drilling on the continental shelf. A brief interval of carelessness off Santa Barbara appears to have cost the oil industry almost a decade of extremely costly delays.

However, other factors were involved as well. One of these was the intervention of state and local NEPA process. These agencies had gradually realized that the development of the Outer Continental Shelf (OCS) was fundamentally different from development nearshore. Nearshore was state land, OCS was federal. Nearshore, the state, and local governments such as the City of Long Beach, bore the environmental, social and economic costs but collected the royalties. They also bore these costs for OCS development, but the federal government reaped the royalties. Perceiving in this an injustice, many state and local governments sued to stop drilling until a new equity could be established. Thus non-federal governments tended to side with environmentalists in delaying development.

On the other side, it does not seem likely that the oil industry was united in a maximum push for OCS exploration and development. During the 1960s and early 1970s, the major international companies had an alternative source of oil, the high quality, extremely cheap, and seemingly limitless crude of the Persian Gulf. Thus, these companies were not under great pressure to discover new domestic reserves. Indeed, the federal government offered them financial incentives to do so on the grounds that a healthy domestic industry was necessary for national defense. Likewise the oil industry was not under great pressure to prepare for OCS exploration. Development of containment booms for oil spills and the like was proceeding but not as rapidly as later events were to prove desirable.

Then came the oil embargo of 1973 and Project Independence to open the OCS as rapidly as possible to develop domestic reserves and eliminate the necessity for imports. What developed rapidly was not oil but paper and talk about the large number of uncertainties and conflicts that had been identified but not resolved in the previous decade. It would be difficult to conceive of a time when the United States was more vulnerable to an oil embargo than in 1973. Given time, conflicts regarding major issues in this country are resolved in the public interest as it then appears to the Congress and the high courts. A decade earlier, rapid development of offshore oil would have occurred without special consideration for the environment. A decade later, or a little more, the development would have occurred with equal speed even though special consideration for the environment was a normal cost of business. In 1973, unfortunately for us, or brilliantly on the part of OPEC, the process of reasonable compromise in the public interest was in midstream. Despite the most obvious peril to national security the country was unable to act, and exploration and development were stalemated.

The period of 1973-1980 was one of gradual resolution of misunderstandings and uncertainties: the polarized groups learned how to communicate and compromise; and major questions were resolved in the courts. A byzantine procedure for offshore leasing was accepted, with reasonable grumbling, by all interested parties. Each step in the long elaborate schedule was known for five years ahead, and the federal government was at last ready for Project Independence on a scale that the country would accept. Meanwhile, however, the potential of OCS oil and gas had been tarnished by the limited exploration that occurred during this interval of uncertainty. Two great and promising structures, the Destin anticline in the Gulf of Mexico and the Great Stone Dome in the Atlantic, were drilled without success.

The election of President Reagan brought a new administration which assigned a high priority to rapid development of energy resources on public lands. Unlike the Carter administration, however, the new administration did not believe that preserving the painfully constructed, awkward, but smoothly working, compromise procedure for OCS leasing was necessary to speed development. Secretary Watt issued statements that were widely interpreted as indicating the end of mandated equality in consultation with industry and environmental interests. The administration also proposed two actions which indicated the compromise procedure was being abandoned. First, it proposed to lease tracts off northern and central California where federal evaluations had showed the resource potential was small and the environmental risk great. It withdrew the proposal under fire from environmentalists, state officials, and the Republican politicians of California. It also proposed to eliminate state governments from the review of the leasing procedure until it was too late for protests to have any effect. The state governments would not accept that change in the compromise leasing procedure and once again the administration had to retreat under fire. Thus, the first statements and actions of the new administration regarding OCS development threatened to revive the stagnating controversy of the 1970s.

So much for the past and present. We are now almost ready to turn to an examination of what has been learned about OCS development during the past decade with the goal of evaluating the logic and wisdom of the compromise leasing system as of 1980, and speculating on the probable effects of the changes that are now under way. Before doing so it may be useful to review the leasing system of 1980 and the steps that consumed about five years between initial planning and issuance of leases for the OCS.

The preparation of a programmatic environmental impact statement requires a long lead time to survey the environment, geological structures and hazards, and to make a general evaluation of resources. The preparation of the report, governmental evaluations, and public hearings likewise require much time but the duration of the various steps has been determined by courts, or explicit compromise, to be as rapid as is reasonable. During this opening period, oil companies are making their own surveys, under government permit, to evaluate the potential of regions of the shelf and identify promising structures. If the environmental impact is judged

acceptable, the leasing process begins. The oil industry, state and local agencies, and the various departments of the federal government indicate the tracts that they do (industry) or do not (government) want offered for leasing. The Geological Survey makes detailed studies of the geological structure, potential geological hazards, potential resources and net worth of each of the tracts under consideration.

Using this and information from other government agencies and outside interests, the Secretary of the Interior then decides which tracts to offer for leasing. A lease sale ensues and the Secretary decides which bids to accept. His decision is based largely on a ritualized comparison of the bids with the estimates of net worth made by the Geological Survey. By late 1980, many decisions were on record and variations from the ritual were largely circumscribed by the likelihood of legal challenges that would delay completion of the sale. Once the sale was accepted the successful oil companies could apply for permits to drill which were granted only after they could demonstrate that all potential hazards were identified and drilling would be safe, free of pollution, and meet the multitudinous requirements of the law. That might take another two years even if the companies were eager to drill—and often they were not.

Interested Parties

The leasing system by 1980 was a compromise accepted, if not happily, by interested parties who by court action, public appeal and congressional lobbying had shown that their views had to be accommodated in order to prevent a stalemate of development. These parties are generally considered to be organized as environmentalists, industry and government but this grouping obscures a great diversity of views. Changing the system is by no means a simple matter of obtaining acceptance by three groups who agree not to go to court.

Consider industry. By normal business standards even a small oil company is quite large, but even so the great international companies have immensely greater resources and often different objectives from the small domestic companies. Moreover, the international giants themselves have very different ratios of foreign and domestic reserves, and wide variations in the corporate mix of exploration, refining and marketing. Some companies prefer to share information, some prefer joint ventures on bidding, others are secretive and solitary. Further, company policies change; the most aggressive bidder on one lease sale may not even participate in the next. Thus, the whole of the oil industry is united on only a few major issues concerning government policy and not at all on the details of the OCS leasing process.

The federal government is at least as diverse as industry with regard to having components with different and conflicting views. The president sets policy, the implementation of which is monitored by the Office of Management and Budget, but either the policy must conform to pertinent laws, which are often themselves contradictory, or else Congress must be persuaded to change the laws. Moreover the policies are implemented by departments and independent agencies that are charged with differing and commonly contradictory responsibilities. The development of the OCS is of concern to most components of the federal government which must confer and, if necessary, battle to protect the interests with which they are charged.

The Department of the Interior may seem monolithic from a distance, but within it are the Fish and Wildlife Service, the Geological Survey, and the Bureau of Land Management which have quite different roles in OCS leasing and development. FWS in its role of protector of wildlife and fisheries is basically an institutional impediment to development because, at best, it will not oppose it. The USGS as resource and geological hazard evaluator, is institutionally neutral. However, the USGS also has a role as promulgator and policeman of safety regulations and exploration and development plans and in that role it is required to be an impediment to speedy action. BLM in its role as manager of leasing is widely perceived as favoring development.

Most other agencies have an institutional bias regarding the OCS. The Treasury Department always wants money (so does OMB) and that has a powerful influence on the terms of leasing. Treasury wants money now—so it favors bonus bidding over profit sharing in the future. Defense wants to protect its missile ranges, submarine operating zones, and so on, and thus

is an impediment to leasing even though it would like more domestic oil. State is concerned not only with the boundaries with Mexico and Canada but also the implications and trade-offs inherent in extending the boundaries into the deep sea. State moves slowly. Commerce is concerned with commercial fisheries (NOAA), and Transportation with maritime safety (Coast Guard) and both are institutionally an impediment to development. So is the Environmental Protection Agency.

The Congress makes the laws and can set them aside as it wishes. The individual members have very different opinions regarding OCS development, particularly in their own states or districts. One senator will favor OCS leasing off his state because of the jobs and revenue it brings, and another will oppose it because of the detriment to coastal property values and possible environmental degradation. Even so the Congress occasionally achieves a concensus to oppose an action proposed by the administration. The Congress, thus, tends to be an impediment to the OCS development but can be the reverse.

The divergent views of all these components of the federal government were accommodated in the deliberate procedures of OCS leasing in 1980. They will have to be accommodated still if the procedures change.

Scientific Information On Environmental Costs

Very little was known about many aspects of the continental shelf when the National Environmental Policy Act was passed. Fishermen, scientists and government agencies had mapped the depths, surface sediments and, most of all, the fisheries. However, drilling and coring were far from adequate to evaluate the safety or even feasibility of major engineering projects, and the effects and persistence of a major environmental impact were largely conjectural. The government moved cautiously to remedy this ignorance through the usual studies by committee, including some from the National Academy of Sciences. From these emerged recommendations for field and laboratory studies and for institutions to fund and implement them. A decade has passed; let me make some brief comments on our present understanding of some of the important questions and issues of the late sixties and early seventies.

Baseline Studies

In order to observe a change in the environment resulting from some action such as an oil spill, it is necessary to make observations before and after. A decade ago, information was lacking on the frequency and distribution of impacts that would result from OCS development. Thus it seemed reasonable to attempt to survey the continental shelf environment to serve as a baseline for future comparison. This program under the Bureau of Land Management was largely a fiasco. Comparatively large amounts of money were poured into contracts for routine surveys of pelagic and benthic life, sediment, properties of sea water, and so on. Short term changes in the environment began to be documented, long term changes began to emerge. Unfortunately, the data had little utility and led to few useful syntheses or generalizations. Attempts were made to keep the program going; outside reviewers made suggestions; but better uses were found for the funds. It is not possible to know everything about the whole continental shelf that you will wish you knew in the future. Research must focus on problems.

Large Oil Spills

One of the priority programs connected with Project Independence was the compilation of a complete record of oil spills. This now exists in computerized form, and it has resolved many critical uncertainties. Most large oil spills result from tanker grounding rather than from oil exploration or production. Moreover, tanker design, operations and safety are relatively difficult to control because the ships typically sail under flags of convenience. In contrast, OCS exploration and producing can be regulated and controlled at whatever level a nation desires. The Ixtoc blowout showed that an extraordinarily productive well can pour out more oil than even the largest tanker, but, with U. S. safety regulations, the blowout would have been highly unlikely.

Many large oil spills have now been studied and in most circumstances the effects appear to be cosmetic and economic rather than permanently destructive. Large numbers of individual plants and animals are killed, particularly cormorants and other diving seabirds. A large spill that covers the whole range of an endangered species could be the end of it. However, most of the effects of the oil spill soon diminish or vanish and the area of the spill is reoccupied from the edges. A major exception exists in polar and subpolar waters where tar freezes in the winter and only partially melts in the summer. Thus, there is new pollution each summer for what may be many years. This is a particularly sensitive point for evaluating environmental hazards on the OCS around Alaska.

Small Oil Spills

Small spills seem to be inevitable where oil and machinery are in use. Oil comes into the sea in some rough proportion related to the number of users and the duration of use. A surprising fraction of pollution of coastal waters, for example, comes from dumping old crankcase oil from private automobiles into sewers when the oil is changed. Oil is spilled occasionally in every phase of its discovery, production and transportation whether on land or at sea. There has not been sufficient time to determine the long term effects of these chronic discharges and one should not underestimate the possibility that they may be serious. However, grounds for limited optimism appear to exist regarding chronic discharges. Natural underwater oil seeps, such as those off Southern California and the Caspian Sea, are such discharges, and the areas are not biological deserts. Even in the vicinity of the persistent seeps near Santa Barbara, commercial and sport fisheries for lobster and abalone have thrived for decades. Likewise offshore oil and major fisheries have been intermingled in the Gulf of Mexico for a long period.

Conservation and Alternative Energy Sources

Regardless of the expected balance between energy gain and environmental loss, it might be argued that no loss should be accepted in the parts of the OCS that are the most beautiful, most productive of fish, or nearest to valuable shorelines if there is no real need for the oil under them. This point was the basis for reluctance to develop in many areas a decade ago and remains so today in some places. Off Santa Barbara, for example, where the coast and sea are very beautiful, the alternative uses for fishing and recreation are substantial, and many people live in valuable property overlooking the sea, it is possible that some oil fields should not be developed. The desirability of withholding development depends on a balance between the benefit to some of the people of Santa Barbara and a small loss to everyone else in the nation.

The remarkable success of conservation in reducing our imports of oil may seem to give encouragement to the argument that we have enough and do not need to despoil the environment to get more oil. However, there is no prospect of conservation adequate to eliminate oil imports by itself. Thus, energy development in one part of the nation can be withheld only by producing more of it in another. The future of nuclear power, at the moment, is uncertain. It appears that it will be some time before there is any possibility of a concensus favoring significant expansion to replace natural gas and oil even for central power production. In contrast, an enormous expansion of mining and burning of coal is in prospect; by the turn of the century coal will replace oil and gas for many uses. The cost will be great. Coal mining is notoriously dangerous compared to other forms of energy production, and pollution by coal smoke has already expanded from the region of burning to form acid rain far downwind. There is a real prospect that expanded coal burning will accelerate the present increase of carbon dioxide in the atmosphere which may cause significant changes in the climate. Thus, with the exception of national parks and wilderness areas, it may be difficult to justify excluding development of oil and gas on federal lands.

Scientific Information on Resources and Economic Benefits

As long as it was believed that the nation's and the world's supply of oil and gas were inexhaustible, the only questions related to public policy were about subsidizing domestic industry through tax exemptions and tariffs. However, once King Hubbert identified the first signs of the present shortages about fifteen years ago, it became apparent that it would be desirable to know how much oil and and gas remained to be discovered. Widely disparate estimates attracted attention to the question of undiscovered resources and clouded rational discussion of, among others, the development of the OCS. If there was as much undiscovered oil and gas on land as estimated by Zapp and McKelvey of the USGS, the incentive to bear environmental costs offshore was greatly reduced. If Hubbert, at that time also of the USGS, was correct, little oil remained to be found in the land area of the 48 contiguous states, the petroleum resources offshore were desperately needed, and pollution and environmental degradation might have to be endured.

While this policy-level question was being debated, the National Environmental Policy Act was passed and it required that resource geologists make broad estimates of the undiscovered oil and gas in the area of each lease sale in order to compare the benefits with alternative ways of producing energy. Moreover, the leasing procedure incorporated bonus bidding and it required that geologists and economists make very detailed analyses of the oil and gas in each nine-square-mile tract and then determine the net worth. Thus public policy, the law, and regulations all required that federal scientists make accurate estimates of reserves prior to drilling. We shall now examine the evidence that they, or anyone else, are able to do so.

Methods of Evaluating Undiscovered Resources

The fact that only one new-field-wildcat well in seven is successful gives a fair indication of the reliability of detailed estimates of undiscovered resources. Not that the ability to make estimates is uniformly distributed. Most big discoveries are made by big oil companies that have the professional staffs to assess oil potential. Nonetheless putting a value on something not yet found is a probabilistic exercise and the method used depends on the quantity and quality of available information. Although ignorant of detail, one can make a reasonable assessment of the oil potential of a continent. Likewise, if one finds an unknown structure in the midst of the West Texas oil province, one can be reasonably sure of its potential. The great problems of estimating undiscovered resources lie between these extremes because of uncertainties and gaps in information and questions about the significance of methods of analysis.

The most appropriate method for resource evaluation when one is largely ignorant is to appeal to general geological knowledge and analogy with thoroughly explored regions. Much is known about the average organic content of different types of sedimentary rock and its variation with environment of sedimentation. Increasingly, the thermal history of sedimentary rocks can be analyzed theoretically, and thus the possibility assessed that the organic matter has been converted to oil and gas. Much is known about the physical properties and distribution of types of sedimentary rock and how they vary in time and space. Moreover, the whole world has been reconnoitered, although sparingly in places, by a century of painfully slow geological exploration on foot, and a few decades of very rapid geological and particularly geophysical exploration at sea and from satellites. Through this reconnaissance, many large structures have already been identified off the margins of all continents except, possibly, Antarctica. Thus, careful analysis of existing data permits a general evaluation of the petroleum potential of different regions and provinces. This method of estimating by analogy was once commonly used, by default if nothing else, to evaluate the prospects of wholly unexplored sedimentary basins. It is becoming obsolete as more information accumulates.

Different methods are used in a more advanced state of petroleum exploration. For example, detailed geophysical mapping and a few stratigraphic test holes greatly improve the basis for estimating undiscovered resources. Crucial information on sand to shale ratio, sand porosity, traces of hydrocarbons and so on may cause major revisions of resource estimates. Are they then reliable enough to meet the requirements of NEPA or the need for resource estimates for policy purposes? While I would expect a wide range of opinions on this question, I believe that we do not know the answer because our only experiments to seek one are inconclusive. These experiments have been the leasing of virgin regions of the OCS such as the Baltimore Canyon and Carolina embayment regions in the Atlantic, and the Gulf of Alaska. The leasing of Georges Bank and the Bering Sea shelf will yield more experimental tests of our ability to respond to the requirements of NEPA. At present, however, no region that was leased because it was thought to have oil has been wholly abandoned. Future exploration may prove successful and immediately change the odds that resource estimates generated for the NEPA process mean very much. On the basis of drilling now completed, however, it appears that neither the federal government nor industry is able to make very useful estimates of the potential of virgin regions. Fortunately, industry finds it economic to accept the unfavorable odds, and continues to bid for leases and drill despite the enormous costs.

Estimating undiscovered resources in a known oil province, such as the Gulf Coast off Louisiana is much more reliable than virgin regions. At the very least, one can be confident that more oil will be found in each lease sale. The uncertainties thus are reduced to the tract level where they are very uncertain indeed—as I shall shortly show. First, however, I would like to discuss the controversy that arose over resource estimates by the USGS because it involved the summation of data from all known oil provinces and shows how critical the method of estimating may be.

Controversy Over USGS Resource Estimates

By the early 1960s more than 300,000 exploratory wells had been drilled in the 48 contiguous states for a total of more than a billion linear feet of probes for oil and gas. The United States was, and is, by far the most intensely explored area in the world. If it is possible to estimate the undiscovered oil and gas resources of any place in the world, the United States should be it. However, estimates made by different people in the same organization at the time differed enormously because of the assumptions and methods utilized. As late as 1972, most concerned people in the USGS, following Zapp and McKelvey, estimated 230 billion barrels of undiscovered oil and natural gas liquids in the 48 states on land. Hubbert estimated less than 40 billion barrels. At roughly 6 billion barrels per year consumption, that difference implied either an urgent or a leisurely response to national energy needs.

Zapp and others argued that only a fraction of the United States had been drilled with holes so closely spaced as to find all the oil. They further reasoned that the oil was evenly distributed and therefore if, for example, half were drilled then the undrilled half contained the same quantity of oil as had already been discovered in the United States. Hubbert reasoned that the chance of finding oil at a given time in the United States could be measured by the success rate, namely the volume of oil found by exploratory drilling for some arbitrary distance—which is equivalent to an arbitrary number of holes of constant depth. Hubbert devised a way of reconstructing the history of the success rate and found that it had declined exponentially with time. He assumed that it would continue to do so and was able to determine the total amount that remained to be found—which was shockingly small.

Most oil companies that made comparable estimates agreed with Hubbert, and the others in the USGS began to revise their estimates downward. George Sharman and I investigated this problem because of its bearing on alternatives to OCS development. We found that Hubbert's history of the success rate was what would have occurred if the United States sedimentary rocks had been drilled at random, and we investigated the implications of mathematical models of random drilling. The models showed that the largest fields tend to be discovered first simply because they are the biggest targets. Oil fields range widely in size, and we showed that if they are discovered by random drilling, the number of giant fields is depleted relatively rapidly, the intermediate fields less so and the smallest fields very slowly. The success rate for each size class declined exponentially but at different rates.

Any discussion of undiscovered reserves ought to consider three variables: the total amount of undiscovered oil ultimately recoverable, the size distribution of the fields, and the maximum rate of extraction. The controversy between Hubbert and Zapp and followers largely focussed on only the first point and thus, in retrospect, was largely meaningless. What Hubbert said was correct but it is possible that Zapp's conclusion, if not his logic, was not too wrong. The key is field size. Most of the oil discoveries analyzed by Hubbert were in giant fields and for giant oil fields his analysis is beyond

dispute. However, concealed within the data are discoveries of small fields and when they are separated it appears that the success rate is declining either very slowly or, for the smallest fields, it is actually increasing at present. Thus, the method pioneered by Hubbert is incapable of determining the total amount of oil in small fields. By other, more speculative methods, I have surmised that small fields contain 20-200 billion barrels of oil. Consequently the uncertainty about small fields almost bridges the gap between the estimates of Hubbert and Zapp regarding undiscovered recoverable oil.

This attempt to quiet a controversy should not for a moment obscure the critical importance of another of Hubbert's discoveries, namely, the success rate for all sizes of fields collectively is declining exponentially. Small fields may provide a very long tail on the decline curve but the nation has a finite capacity to drill. Even if that is greatly increased, the amount of oil discovered per year will be much less than at present and wholly inadequate for the nation's needs. This point never was controversial, but it is all that is required to demonstrate that in the future the United States will obtain oil from the continental margins, or Alaska, or imports, or do without very much.

Economic Evaluation of Tracts

We now return to the role of resource evaluation in the final stage of the leasing procedure—bidding and acceptance of bids on individual tracts. When it took office, the Carter administration viewed the procedures then in use with profound distrust. Public interest and environmental groups had expressed doubts and these were reflected in the administration. It was believed, by these groups, that the Geological Survey lacked the information or the competence of the great oil companies and thus was unable to protect the public interest by making accurate evaluations of the net worth of tracts. The fact that the USGS commonly put lower values on tracts than the highest bidder was taken as evidence in support of these beliefs. The same groups and the administration also were deeply suspicious that oil companies might be acting in collusion to suppress competition, keep bids low and generally act contrary to the public interest. Consequently the administration instituted an elaborate system of monitoring and reviewing such things as bidding patterns of different companies, percentage of tracts receiving multiple bids, similarities and differences in bidding by various companies, and so on. Nothing useful ever came from this effort by lawyers and accountants.

Were these doubts, beliefs and suspicions justified? To answer this question it is necessary to review the economic evaluation of tracts. As practiced by the Geological Survey, geologists and petroleum engineers first prepared highly detailed structural maps of different stratigraphic levels of the tract. These provided the basis for estimating the location of any traps for oil or gas. Then from stratigraphic information and evaluation of hydrocarbon potential, estimates were made of the volume of oil and gas in the traps, the chance they might be empty, the percentage of the hypothetical oil and gas that might be recovered, and the rate of production of the oil and gas. Engineers then evaluated the types and numbers of exploratory

holes, production platforms, pipelines and supporting facilities that would be needed to develop the field, as well as the services necessary to produce. Working with economists they then determined the amount and flow rate of money necessary to develop and ultimately close down the field. Then the USGS received from elsewhere in the Department of the Interior estimates of the rate of inflation and interest rates during the lifetime of the field. From all this information, the USGS estimated the present worth of the tract and that was equivalent to the "bid" of the government in the lease sale. In general, if that bid was not exceeded by one from industry, the tract was not leased.

Oil companies went through all these steps in order to prepare their bids but in addition they had to consider alternative uses for their money, their special needs for oil and gas as a component of the whole corporation which might include refineries and retail stations. These additional factors probably accounted for many observed changes in company behavior.

When I became director of the Geological Survey, I immediately tried to establish whether the doubts, beliefs and suspicions about the leasing procedure had any basis in fact. It soon became evident that the ongoing government analyses were largely incapable of answering the pertinent questions. Meanwhile a vast amount of information had been collected which could provide answers if properly examined.

The first question we addressed was whether the USGS had access to as much useful information as oil companies and whether it had the professional and budgetary resources to analyze the data as well as industry. By statute the Survey has access to all geophysical data acquired on the OCS, but, in these days of computer processing and signal enhancing, raw data are of comparatively little use. Inasmuch as some oil companies can, and apparently do, spend much more for data processing than the Survey, it is quite possible that they have more useful information going into a lease sale than the government. However, this information consists largely of speculative interpretation which would vary from geologist to geologist and is not necessarily correct. Only once, that I recall, did it appear that some, not all, companies had made a significant advance in computer processing just in time for a lease sale and that it might have given them an advantage in determining geological structures. However, the structures have yet to be drilled so it is by no means certain that the winning bidder thereby gained a financial advantage as well. Some oil companies, for example, utilized bright-spot interpretations in advance of the USGS and were sure that they could identify oil and gas prior to drilling. Accordingly they bid most of a billion dollars for tracts on the Destin anticline—which came up dry.

The spectacular failures and successes of resource evaluation prior to drilling are publicized but the underlying assumption—that estimates are closely related to reality—had never been tested. That is, it was assumed that the estimates of government and industry ought to correlate with each other even though it had not been demonstrated that either set of estimates meant very much. To examine this question we processed data in open government files regarding more than a hundred tracts which had been leased and successfully drilled sufficiently to establish the reserves of oil and gas

within reasonable limits. We compared the resource estimates by the USGS with the reality found by the drill. There is unquestionably some correlation between estimates and reality but the uncertainty is spread over two orders of magnitude. If the actual amount is 10,000,000 barrels, the Survey estimates range rather uniformly from 1,000,000 to 100,000,000. If it is 5,000,000 barrels the Survey range is from 500,000 to 50,000,000 and so on. We cannot make the same type of analysis of industry estimates because they are not announced publicly. However, the large fraction of leased tracts that prove dry, suggests that industrial estimates of resources leave something to be desired. The most important fact about wildcat drilling is that only one well in seven finds a new field. The important corollary is that the oil industry can make money even if it is wrong six times out of seven. Daring exploration and investment overcome the obvious weaknesses of resource assessment. It seems curious that the government, which is institutionally timid, should employ the only leasing system that requires resource assessment.

Another important fact about wildcat drilling is that the big companies with the best information have better success ratios than industry as a whole. Obviously, if you must make estimates of undiscovered resources, it pays to make good ones. Since the government insists on making estimates, it is pertinent to see whether its estimates are like those of the best informed companies. Corporate resource estimates are unknown but in some circumstances it is possible to separate bidders into two classes: those who have specially valuable information and those who do not. The Gulf of Mexico contains a checkerboard of tracts which may be unleased, leased but undrilled, and drilled and producing or abandoned. The oil prospects for large areas are clearly favorable, and the costs of development are well-known. Thus, difference in bids reflect differences in information about the geology immediately in the vicinity of a tract offered for leasing—and also differences which are unrelated to resource estimates and which I shall simply call "boldness." The specially valuable information comes from adjacent tracts which have been drilled but are neither producing nor abandoned. Thus, only the companies that own the leases and the Geological Survey know what the drilling has disclosed. In such circumstances our analysis showed that Survey bids tended to agree with those of the best informed companies. Less informed companies generally tended to bid higher than the informed ones: thus boldness, not information, was the determining factor in bidding.

Other questions we addressed were related to whether USGS bidding adequately protected the public interest. Why, for example, were Survey bids so often lower than the highest industry bids? This was viewed as a serious fault when I first began to attend Department of the Interior meetings on OCS leasing. Upon inquiry, it developed that the whole, widely publicized matter was one of bureaucratic confusion. The Department had never asked the Survey to produce bids that averaged any particular value relative to the average bid of industry. It would have been easy to do so. In fact, the Survey acting for the federal government was making, and is still making, bids on an entirely different basis from all corporate bidders.

The companies bid with the objective of winning, that is being high bidder, on some fraction of the tracts. They achieve this objective in a generally random manner in that the number of leases obtained by any single company is correlated with the number of bids made by the company. To this extent, bonus bidding is merely a high stakes lottery. Sometimes a company bids high, sometimes low, and if it tries a certain number of times it succeeds a proportionate number of times. If it does not win so often as it wants, it need merely up each bid until it does. A company quite legally, and at its own expense, rigs the lottery. The sole exception is the Geological Survey which is required to bid on all tracts and hardly ever makes the highest bid, or "wins." The Survey is instructed to estimate resources and net worth of tracts but it receives no instructions about being bold nor about how often it is supposed to win.

In sum, the whole bonus bidding system is flawed by the difficulties of making significant estimates of undiscovered resources. It works but many systems are working equally well elsewhere in the world and in the nation. Whether it works to protect the best interests of the nation depends on how those interests are defined. If the objective of public policy is to speed discovery of oil, there are far more appropriate ways to achieve it than bonus bidding. A low stakes lottery with a commitment to immediate drilling, is an example. Even if bonus bidding is retained government evaluation of tracts is a costly and time consuming way to protect the public interest.

If public policy is to obtain a fair return to the treasury for the minerals on public lands, or even to balance that consideration with the national need for oil and gas, the bonus bidding system needs modification. Many tracts have been offered more than once and the treasury has benefited from the delay in receiving an acceptable bid. Thus, withholding tracts with low bids is financially desirable. The government could determine in advance what fraction of tracts it will withhold. Such a determination would eliminate the need for detailed federal estimates of tract resources. If the government wants to maximize the return to the treasury while retaining bonus bidding, it should pay attention to the fact that the highest bid for many tracts is at least double the next highest bid. One company apparently felt very bold in its bidding. In the lease sales that is known as "leaving money on the table" because the bid was larger than needed to win. To maximize its return from bonus bidding, the government should lease only to the boldest companies who bid far more than the next boldest and it should also offer tracts again soon to continue the process until leasing is completed.

I do not want to conclude this section without making clear my own position on two matters. First, I believe that the Geological Survey is perfectly capable of making resource estimates as well as anyone else and can protect the public interest if policy-making officials will just define that policy. Second, I believe that the nation should give priority to finding oil quickly rather than to filling the treasury quickly.

Some Controversial Issues Of the Decade

Federal Oil and Gas Corporation

Although the diverse oil companies are united on few issues, they solidly oppose the creation of a Federal Oil and Gas Corporation (FOGCO) as proposed by some congressmen and by consumer and environmental groups. The advocates believe that the competition of FOGCO would help keep the price of oil and gas from rising and generally protect the public interest. The oil industry believes that the federal government is incapable of taking the risks of oil exploration or of wisely managing oil production while paying only a fraction of the salaries offered by industry. The dominant issue about FOGCO, I believe, is one that rarely surfaces: it is the issue of nationalization of the oil industry. All over the world, governments of every political and economic persuasion have been nationalizing petroleum exploration, production and processing. The governments tend to have a department which administers and contracts for all phases of operations. The international companies that used to find oil for themselves are now contractors for finding oil and so on. Creation of FOGCO would be a change in the status quo, and its opponents must surely be uneasy about what might follow.

Although it has not been widely appreciated, information respecting the debate on FOGCO has been accumulating during the last decade because the federal government has been running an oil company in Alaska. The U.S. Geological Survey has been charged with assessing the oil and gas potential of the National Petroleum Reserve in Alaska (NPRA), the former Naval Petroleum Reserve 4. To do so, the Survey has been spending $200–250 million per year in drilling holes and analyzing the results. Like most government oil companies the Survey has only a small group of government scientists to monitor and analyze. A "small" oil company does the drilling and provides logistic support by contract, and a geophysical company, of the sort hired by industry, handles much of the geophysical exploration and interpretation.

The record exists. Who can say that the federal government is not capable of running FOGCO? Well, the record does exist. Let us examine what happens when the government has its own oil company. In the first place the NPRA exploration was successful in assessing the oil potential of the reserve but it did not find any commercial fields. Whether industry would have made any discoveries for the same amount of money is wholly conjectural, but several corporate executives have indicated they would not have had the same priorities as the government. Instead, these executives would have focussed on the most promising areas rather than trying to obtain uniform information about the entire NPRA. Whether the nation is better off having more information or more oil at the moment is another question, but on the record, FOGCO might be used to serve purposes other than the short term discovery of oil and gas.

Something can also be learned from the record about the absurdities and waste of running FOGCO when the government is divided about what to do. From 1978–81, the Office of Management and Budget wanted to eliminate the NPRA exploration to save money, and the Congress wanted to continue the exploration for various reasons ranging from implementing FOGCO to speeding leasing to industry. Time and again in the budget cycle the Congress ordered, as is its right, the appropriation and expenditure of public funds for NPRA. Time and again OMB struggled, procrastinated and delayed. One might regard these actions as normal for the federal government but they have to be put in the context of Arctic logistics. To abstract the problem, in a region of ice and frozen tundra, the drilling rigs can be moved only by giant sleds and only when the ground is covered with snow. Otherwise the scars of moving probably would last for centuries, and indeed moving might be impossible when the surface of the permafrost is melted. Moreover, the drilling rigs are under contract and if funds are not available at a certain time, the contract is voided and the rigs are shipped south or contracted to some other company in the Arctic. Substantial penalty clauses cover every step of the drilling contract.

It should be remembered that the administration and both houses of the Congress were then controlled by the same political party. Nonetheless, the USGS, managing the exploration of NPRA, received contradictory orders for days, weeks and months on end as the winter snows melted and the contract deadlines came and went. It is no way to run an oil company.

The thesis that the federal government is inherently unable to accept the risk necessary for exploratory drilling was also tested repeatedly during this period and, in my opinion, the thesis was verified. The federal civil service does not appear to be a good training ground for taking risks in the $100 million range. Likewise political appointees all too commonly think in terms of the consequences of costly failure rather than of the immense rewards of success.

On-structure Drilling

The amount of oil discovered on an OCS lease is only very poorly correlated with the amount estimated by the USGS or with the number and size of bids by oil companies. The reason for this is simply that more information is needed to improve the correlation. One would assume that all parties to the leasing procedure therefore would welcome more information before the lease sale. This assumption is supported by the popularity of Continental Shelf Stratigraphic Test (COST) drilling in which a group of oil companies band together to drill a well purely to collect information. In most respects this COST program is like the stratigraphic test program conducted by the USGS in the National Petroleum Reserve in Alaska. However, the NPRA was usually drilled on a structure, whereas the COST drilling is always off structure. Oil tends to be trapped in structures or traps after it has migrated from adjacent rocks. Thus, in NPRA the possibility existed that oil would be discovered in the course of stratigraphic testing before leasing occurred. Everyone agrees that the only conclusive test for oil is to drill on structure. Why then are COST holes not drilled on structure where they would have a change to provide the most useful information of all?

A controversy arose with regard to this question. The oil companies achieved another consensus in opposing on-structure drilling. As a basis for their opposition the companies argued that many holes are needed to thoroughly test a structure, and if the first COST hole were *unsuccessful* then that might discourage the government from offering the structure for leasing, or would at least decrease estimates of its value. They also were troubled by the expectable consequences of a *successful* COST hole. Would the government be content to hold a lease sale without drilling the additional holes needed to establish the limits and reserves in the field? Once the field was defined would the government offer it for lease or merely put it in a new National Petroleum Reserve, or even use it as a justification for FOGCO? I think that this final point, although not vocalized publicly, was the one that united industry against on-structure drilling. Industry does not want any oil to be discovered which is not already privately owned or leased because it is viewed as a threat to the private enterprise system.

Those advocating on-structure drilling were not concerned with this threat or did not think it credible. They believed the drilling to be desirable for two quite different reasons. First they argued that the additional information to be gained by on-structure drilling would greatly improve the economic efficiency of OCS leasing and development. Corporate resources would not be wasted on less promising structures but would be concentrated where the prospects were best. The second argument was that for reasons of national security and policy the United States needs an inventory of its energy resources as rapidly as possible. Discovery of a few major new oil provinces in Alaska or on the OCS would greatly alter our bargaining position with OPEC. On the other hand if the oil and gas inventory, although merely a reconnaissance, were unpromising, the nation would know well in advance that it must conserve energy and turn to other sources for energy. On-structure drilling of all known major structures could proceed very rapidly compared to the full process of sequential leasing and development of region after region and tract after tract.

Until 1979, federal regulations did not permit on-structure drilling, but at that time the issue was raised again and exposed to public comment. The regulations were then changed to the form in which they now exist. COST holes may be drilled anywhere it is safe, either on or off structure. However, the initial step in drilling a COST hole is that a company—or more commonly a consortium of companies—apply for a permit. None have ever applied—at least so far. Thus, the concerns of the advocates who want more information to improve the economic efficiency of the leasing process are not being accommodated and may not be under the present administration. However, those, like myself, who are more concerned with a rapid inventory need not be discouraged. Indeed the present administration may be more inclined to a rapid inventory than the last—provided it is done through a new leasing procedure which I shall now discuss.

Leasing Schedule

The Andrus leasing schedule was designed to open OCS land as rapidly as NEPA, the concerns of special interests, and the resources of the Department of the Interior permitted. The size of the individual lease offerings and their sequence in various regions of the OCS were largely controlled by the capacity of the Department to make resource and hazard evaluations in the regions. By late 1980 the leasing system worked smoothly and slippages had largely been eliminated by making the schedule realistic. From time to time, oil company representatives or environmentalists expressed dissatisfaction with some aspect of the leasing such as the size of tracts offered, the pattern of tracts, or the order of offering. However, Secretary Watt proposes to make changes and it is quite possible that some elements on the industry side of the compromise would now welcome a change even at the risk of controversy. With regard to the leasing schedule, some possible changes are the following:

Accelerate leasing of the most promising structures throughout the outer continental shelf by discarding the concept of sequential regional sales

Accelerate leasing of the most promising regions by changing the order of sales

Accelerate the whole schedule by eliminating some of the steps that heretofore have been considered necessary

Each of these alternatives has some merit if the cost of destroying the compromise is acceptable to the administration.

Most Promising Structures

Public lands are leased in complete blocks except for tracts where external considerations outweigh the estimated economic gain. However, no law or regulation specifies the size of the area; only logistics sets a limit. The present size of offerings, roughly a million acres per sale, is highly arbitrary. When Project Independence accelerated leasing, the government had few people to prepare environmental impact statements and the whole nation had limited resources to collect scientific information about the continental shelf. Likewise industry had limited resources to collect the information it required to bid on tracts. Moreover, the whole infrastructure for public hearings and review was rudimentary and resources to develop that infrastructure were few. Thus, it was only reasonable to concentrate all the available resources upon some subdivision of the continental shelf instead of offering the whole shelf at one time.

The circumstances at present are very different. Much is known about the environment of the shelf; in particular, both industry and government have conducted reconnaissance surveys of the geological structure of almost every part of the shelf. Most of the largest structures with a potential for oil or gas are known. COST holes have provided stratigraphic information in most regions. The sales that have already occurred have produced programmatic and even site specific environmental impact statements. The infrastructure for public hearings and review is in place and all concerned parties have staffs that are adequate to conduct several lease sales of a million acres each per year. Under the present system, the most promising structures in one year's lease sale may be drilled next year, but the most promising structures, already identified, on the whole OCS may not even be offered for many years.

Why not open the whole OCS for nominations by industry? Drilling a million acres of the best prospects would have the maximum potential for identifying new reserves. Likewise, the discovery of a major field in a new region is capable of providing the logistic support, a pipeline for example, that makes smaller fields economic and encourages exploration. Finally, but in my mind very important, leasing the most promising structures of the whole shelf is an effective step toward an inventory of the remaining oil and gas resources of the nation. It is well known that most petroleum is in giant fields, and some understanding exists about the size distribution of smaller fields. Thus, it is only necessary to drill a reasonable number of giant structures, perhaps half a dozen in each potential oil province on the OCS, to make a useful and informative preliminary inventory of the ultimate yield. This is an important objective for national policy planning, and it can be achieved without threat, real or imaginary, to the free enterprise system. Desirable as it may be, however, it cannot be achieved without institutional and procedural changes which will incur some costs and delays.

Order of Leasing

Conceptually, changing the order of leasing is merely a variation of opening a whole OCS at one time. Leasing a million-acre area containing some promising structures is merely substituted for leasing the whole OCS with all promising structures. If one change is possible, probably the other is, and surely leasing all the structures at once is more desirable.

Acceleration by Eliminating Steps In the Leasing Procedure

With the experience of a decade of intense exploration and development, it should not be difficult to reduce or eliminate many of the steps in the leasing procedure which originated because of ignorance or uncertainty. Perhaps it would be more accurate to say that it should not be difficult to *propose* a more logical, briefer, and more economical leasing procedure than has existed. For example, if thousands of tract surveys have shown no sign of archeological remains, it seems reasonable to eliminate such surveys as a necessary step in the leasing procedure. I do not propose that underwater archeology is unimportant or not worth pursuing for itself, but it could be independent of the leasing schedule.

The assessment of natural hazards is absolutely essential before tract development is permitted but according to the leasing procedure it must now be done three times—twice by the government and once by industry. At present the USGS makes broad scientific studies of the causes of underwater hazards and the factors that influence their distribution. Then, it makes a detailed survey of potential hazards in each tract that will be of-

fered for leasing. Then the company that acquires a lease must have its exploration and development plans approved by the USGS for safety and compliance with regulations. The USGS itself has repeatedly proposed the elimination of the middle step as being unnecessary considering that industry cannot obtain approval of its plans without surveying the hazards to prove that engineering designs are safe. This step could be eliminated with a saving of time, manpower and money.

The potential value of the resources in the OCS must be estimated repeatedly according to NEPA and also the concensus leasing procedure as of 1980. NEPA requires in advance of any action a comparison of the potential benefits and losses if the action may have a major effect on the environment. This means that the law requires evaluation of the volume of oil and gas in the area of a lease sale in advance of drilling. However, I have already shown that with present technology and understanding, there is little basis for confidence in pre-drilling estimates of resources. The law, thus cannot be obeyed—as more than one state has contended in suing the federal government to stop OCS development. The suits failed but that was before recent evidence became available. Changing laws, even if unworkable, takes time, however, and it would be challenging to change this one rapidly enough to be helpful.

The second stage in resource evaluation offers more opportunity for economies and acceleration of leasing. Prior to a lease sale, the net economic worth of each tract must be evaluated both by the USGS and by all companies that plan to bid. This requires an extremely detailed analysis of the geological structure and oil potential of the rocks, and a similarly detailed economic and engineering analysis of the cost to produce the oil. It should be emphasized that the final analysis is economic and is highly dependent on estimates of future interest and inflation rates and changes in OPEC's price for oil. The reader need think only of how unpredictably all of these have changed since 1973 to realize that the detailed evaluation of tracts has proved to be little more than a fantasy. One wonders if there is any justification in continuing it.

The tract evaluation is not required by law. It is deemed necessary only because the leasing system is based largely on bonus bidding with fixed royalties. Many other systems are possible and indeed bonus bidding is used in few other countries or even under other circumstances in the United States. If ever there were an opportunity to accelerate and economize on OCS leasing, it is by elimination of tract evaluation and the adoption of one of the many other forms of leasing.

The Future—Balancing Unknowns

The environmental consequences of this age of population explosion, fossil energy depletion, and stockpiling of nuclear weapons resist analysis. It is even unrealistic to believe that we can forecast all the consequences of as brief and simple a matter as the development of the outer continental shelf (OCS). Nonetheless, it appears that we can now identify most of the important factors that will influence the development. Although others may differ I believe that the following are known:

Importing oil by tanker will cause more environmental degradation to the nation, although not uniformly, than development of the OCS.

Utilization of coal will cause more environmental degradation to the nation, and probably the world, than development of the OCS.

The short term environmental effects of most oil spills are largely cosmetic and briefly economic.

The long term environmental effects of multiple spills are unknown but will be greater from tankers than from OCS development in most regions.

Conservation and the contribution of nuclear, solar and other sources of energy will reduce, perhaps greatly reduce, but not eliminate our need for additional fossil fuels during the next two decades.

Development of the OCS thus has the potential of helping solve our national energy problem with a smaller risk to the environment than any comparable alternative.

In this paper I have attempted to show that many of the requirements of the leasing procedure for the OCS were logical in the absence of information when put in force, but they no longer appear so after a decade of acquiring data. Thus, a great opportunity exists for a major revision of the procedure that, once it is in effect, will save time, effort and money. The problem will not be to make a better procedure work—it will be to put that procedure into effect. To do so will require building a new and different concensus among diverse interests just at a time when they are increasingly polarized. Without due consideration for the views of all the interested parties, and appropriate consultation, leasing the continental shelf may be delayed for another decade before a new concensus emerges from the courts.

About the Author

H. William Menard was born in Fresno, California, December 10, 1920. He received his B.S. in Geology (1942) and M.S. (1947) from the California Institute of Technology, and his Ph.D. in Geology from Harvard University (1949). During World War II, he served with the U.S. Navy as a photo interpreter and air intelligence officer in the South Pacific. Wounded in action, he received the bronze star medal, an individual Navy commendation ribbon, seven other ribbons, and six combat stars.

From 1949 to 1955, Menard was employed as a marine geologist by the Navy Electronics Laboratory in San Diego. In 1955, he joined the Scripps Institution of Oceanography as a professor of geology. From 1978-81, he served as director of the U.S. Geological Survey in the Department of the Interior.

At NEL and Scripps, Menard participated in twenty deep-sea oceanographic expeditions in many areas of the Pacific and across the Atlantic. During 1953-56, involved in underwater mapping off the coast of California, he made more than 1,000 logged aqua-lung dives for geological purposes. His scientific studies resulted in nearly 100 scientific papers, including four books.

In 1965–66, Menard served as a technical adviser in the Office of Science and Technology, Executive Office of the President, responsible for marine science and much of the atmospheric and solid earth science.

In 1969, he participated in a National Academy of Sciences study on the environmental impact of a proposed Everglades jetport and also in a similar study in 1970 related to a proposed extension of Kennedy International Airport. He also served on a White House panel to study the Santa Barbara oil spill. He has been a member of the NAS Committee on Science and Public Policy and the NAS Commission of Natural Resources. In 1974, he served as chairman of an NAS Committee to advise the Council on Environmental Quality on the probable impact of developing offshore oil.

Menard's honors include election to the National Academy of Sciences, American Academy of Arts and Sciences, and the California Academy of Sciences; a Guggenheim Fellowship; an Overseas Fellowship from Churchill College, Cambridge University; the Shepard Medal of the Society of Economic Paleontologists and Mineralogists; honorary degree of Doctor of Science, Old Dominion University; Distinguished Alumni Award for 1978, California Institute of Technology.

His professional affiliations include Geological Society of America; American Geophysical Union; and American Association of Petroleum Geologists. He is a Registered Geologist, State of California.