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OUTER CONTINENTAL SHELF POLICY ISSUES

HEARINGS

BEFORE THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS UNITED STATES SENATE

Pursuant to S. Res. 45

A National Fuels and Energy Policy Study

NINETY-SECOND CONGRESS

SECOND SESSION

ON

OVERSIGHT ON OUTER CONTINENTAL SHELF LANDS ACT

MARCH 23, 24, AND APRIL 11, 18, 1972

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SENATE RESOLUTION 45

NATIONAL FUELS AND ENERGY POLICY STUDY

This publication is a background document for the National Fuels and Energy Policy Study authorized by Senate Resolution 45, introduced by Senators Jennings Randolph and Henry M. Jackson on February 4, 1971, and considered, amended, and agreed to by the Senate on May 3, 1971.

The resolution authorizes the Senate Interior and Insular Affairs Committee, and ex-officio members of the Committees on Commerce and Public Works and the Joint Committee on Atomic Energy, to make a full and complete investigation and study of National Fuels and Energy Policies.

This document is published to assist members of the Committee and other interested parties in their understanding of the issues inherent in the formulation of a long-term National Energy Policy which assures the continued welfare of the Nation, including balanced growth, safeguarding and enhancing the quality of the environment, and national security.

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APPENDIX

(Under authority previously granted, the following statements and communications were ordered printed:)

STATEMENT SUBMITTED BY THE OFFICE OF EMERGENCY PREPAREDNESS

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF EMERGENCY PREPARDNESS,
Washington, D.C., May 10, 1972.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate Washington, D.C.

DEAR MR. CHAIRMAN: Thank you for your letter of March 8, 1972, concerning the development of energy resources on the outer continental shelf.

Our submission is enclosed. You will note that we have responded selectively to the questions raised by the Committee for this agency's comment. The basis of our choice is that the Department of the Interior has the requisite experience and is therefore better qualified than OEP to respond to those questions which we have not answered.

Sincerely,

G. A. LINCOLN, *Director.*

Enclosure.

QUESTIONS SUBMITTED BY THE COMMITTEE TO THE OFFICE OF EMERGENCY PREPAREDNESS AND THEIR RESPONSES

Question 1–2. In light of existing and projected demands for energy and the simultaneous requirement to protect the marine environment, what alternative source of energy, other than OCS petroleum from future leases, are readily available and at what economic costs and environmental risks?

The revised Environmental Impact Statement recently published by the Bureau of Land Management for scheduled 1972 OCS lease sales includes a comprehensive discussion of alternative energy sources. Most of the alternative sources listed are not readily available but were included to comply with the court decision. Alternative energy sources that are readily available within a 10- to 15-year time-frame include:

1. Additional onshore oil and gas reserves within the lower 48 states.
2. Alaskan oil and gas reserves.
3. Imported crude oil and gas from Canada.
4. Overseas imports of oil and gas.
5. Domestic coal.
6. Nuclear energy.

Development of additional onshore oil and gas reserves presents minimum environmental risk. Unfortunately, declining domestic exploration indicates that the economic cost of discovering and developing such reserves exceeds the value of such reserves. Barring an unexpected exploration breakthrough, it is unlikely that this source will be ample to supply our immediate energy requirements unless there is a substantial increase in wellhead prices. Even with substantial increases in wellhead prices, many informed individuals believe that we will be unable to supply our future energy needs from this source.

At the present time the delivered price of domestic gas is appreciably lower than alternative energy sources (with the exception of high-sulphur coal in certain locations) and supplies are insufficient to meet demand. Since any shortfall in domestic gas supplies must be replaced by higher cost energy sources (e.g., fuel oil at 70¢/MMBTU), a higher wellhead price for new domestic gas up to the price of competitive fuels would not increase our total energy cost, although it would increase that portion of our energy costs attributed to gas. Consequently, increasing the wellhead price of new domestic gas to encourage increased exploration for gas reserves represents our least expensive method to increase our energy resources. Increased gas exploration would also result in the accidental discovery of additional oil reserves.

In contrast to a gas price increase, increased domestic wellhead prices for oil will directly and immediately increase our total energy costs. To encourage increased domestic exploration for and development of oil reserves without increasing prices, the Government could grant additional tax relief such as increased depletion allowance, investment tax credits, or full expensing of all exploration expenses. Any Government action to improve the economics of domestic production should be coupled with provisions to insure that any increased benefits be applied to increase domestic exploration. One provision that would result in increased domestic exploration would be to limit allowed depletion to the amount of expenditure for direct domestic exploration.

The high bonuses paid for Alaskan leases indicate that substantial oil and gas reserves are likely available from this source at costs no higher than present energy costs—at least the industry apparently thought so at the time of the lease sale. However, Alaskan oil and gas production can be obtained only at some environmental risk. The extent of this risk is discussed in detail in a recently released Environmental Impact Statement pertaining to the Alyeska Pipeline (TAPS). Alaskan oil is vitally needed for our economy, but even if all environmental problems are satisfactorily resolved, the volume of oil and gas from Alaska is unlikely to be sufficient to solve our energy problem. Energy from the Alaskan North Slope could become available by 1976 if construction of the Alyeska pipeline is not further delayed.

Crude oil and gas can be imported from Canada with minimum environmental risk. The oil provinces of Alberta and Saskatchewan have been extensively explored, and substantially increased imports from these areas are unlikely. The Canadian Government has already limited gas exports. The Canadian Arctic holds considerable promise for additional reserves during the 1980s. If significant oil reserves are discovered, their delivered cost could be similar to other energy sources, although large reserves will be necessary to justify building transportation facilities. The delivered cost of arctic gas will almost certainly exceed the present cost of U.S. energy, even if large reserves are discovered. Most likely transportation costs alone will approach present energy costs.

Large Canadian oil or gas reserves offshore the Maritime provinces, or in the Eastern Arctic Islands accessible to water, likely could be delivered to Eastern Canada and the U.S. East Coast at prices competitive with existing energy costs. However, water transportation would increase environmental risks.

While the Canadian Arctic has the potential for supplying an appreciable portion of our projected energy gap during the 1980s, any projection of reserves from this source at this time is speculative. The extremely high cost of development and transportation will require the discovery of giant fields to justify commercial development. Exploration results to date, while encouraging, are insufficient to fully assess the area's potential.

Increased overseas oil imports can be obtained presently at a lower cost than U.S. energy. Recent events indicate that the cost of these imports will likely increase and possibly approach U.S. energy costs. For the period through the 1970s there appears to be sufficient worldwide crude oil reserves (principally in the Middle East) to supply the world's energy needs. However, if producing countries decide to prorate production, a world shortage could develop.

Large volumes of foreign reserves can be imported only at increased environmental and security risks. The vast majority of oil spills has resulted from tanker operations, and not from offshore oil and gas development. Unless we increase domestic or Canadian energy sources, we can expect significant increases in tanker movements at increased environmental risk. We can reduce both the cost of crude oil imports and future environmental risks by developing several deepwater oil terminals to allow handling larger tankers and to reduce the number of unloadings.

Significantly increased imports present substantial risks to our national security. The bulk of such imports will originate in the Middle East. Recent years have shown the willingness of certain exporting countries to cut-off supplies for both economic and political purposes. Further, projections of future oil income to the larger exporting countries indicate that they will accumulate sufficient capital reserves to allow shutting in production for extended periods of time. Consequently, it is not unreasonable to anticipate the possible future loss of a substantial portion of our imports for a sufficient time to materially affect our economy.

Domestic coal represents a potential low-cost energy source but presents serious environmental problems. Transportation costs of coal on a BTU basis are substantially higher than transportation costs of oil or gas. The bulk of the coal in the Eastern portion of the U.S. has a high-sulphur content that limits its use until either coal desulphurization or stack gas cleanup technology is developed. Western coal has a low-sulphur content, but high transportation costs increase the delivered cost in most consuming areas above that of alternative energy sources.

Technology is currently being developed to convert coal to synthetic crude oil or synthetic gas. This will allow reduced transportation costs. However, conversion costs will be high so delivered costs of the converted energy forms will most likely exceed present delivered costs.

Nuclear power will supply an increasing portion of our energy needs. It has the potential of providing energy at lower cost than other energy forms. However, environmental and safety considerations have slowed development of this energy source. For the near term, and until environmental and safety problems are solved, we cannot rely on this source to supply our energy needs.

Other potential energy sources such as shale oil, solar energy and geothermal energy are not readily available at this time. Hydroelectric power does not offer the potential to supply significant amounts of energy.

The OCS offers the potential for yielding significant additional oil and gas reserves. The magnitude of the bonus bids indicates that industry feels that this energy can be produced at an economic cost comparable to existing energy costs. Offshore oil and gas development involves some environmental risk, but the overall risk appears less than the risk from alternative energy sources that will be substituted if the OCS is not developed.

Question I–3. What would be the economic, security of supply, and environmental consequences of alternative strategies for scheduling of OCS resource development (e.g., postponing development and consumption of these resources until the need for them is greater due to increased costs or unavailability of imported oil)?

Alternative strategies for OCS resource development are as follows:

1. Shut down OCS operations (See question K–5).
2. Continue present operations but delay further leasing and exploration.
3. Continue present operations and continue exploration (geophysical and core tests) in undeveloped areas but postpone testing of any prospects.
4. Same as 3 but adequately test prospects discovered to prove reserves. Delay development of any discovery.
5. Continue present operations, and explore, test and develop new reservoirs but shut in new wells as an emergency standby (see question L–1).
6. Continue active operations on OCS.
   - (a) Slow schedule, exploration and development.
   - (b) Rapid schedule, exploration and development.

We do not feel that alternative 1 has any merit (refer to question K–5).

From a national security point of view we are interested in achieving a maximum combination of U.S. production, and standby reserve capacity. The goal is to maintain the ability to supply U.S. energy requirements with minimum rationing or dislocations in our economy during any disruption of imported supplies.

Alternatives 1 through 4 would result in increased imports without developing equivalent standby capacity, and this would tend to imperil our national security. Lead-times are such that relatively little supply could be obtained during a crisis from any discovery not developed prior to the time of crisis. In alternative 2, a minimum lead-time of approximately 3–4 years would be required to develop substantial additional production, even assuming a crash program. Presumably, alternatives 3 or 4 would reduce lead-time since exploration would have been conducted in advance. However, previously discovered fields could be rapidly developed only if adequate rigs were available, platforms had been predesigned, and platform steel was available. Since, under alternative 4, there likely would be little activity immediately prior to the emergency, there would be few, if any, rigs available on short notice. As a consequence, appreciable delays would likely occur in assembling equipment to start development.

Thus, a minimum lead-time of 2 to 3 years seems likely under alternative 4. Alternative 5 would allow rapid response to an emergency. However, as discussed more fully in question L–1, the cost would be high and, in the short term (i.e., the next 10–15 years), total U.S. capacity would likely be less under this option than if full activity is continued (alternative 6).

In the long term (i.e., 15–20 years), alternative 6 could result in depletion of U.S. reserves and lead to greater import requirements if alternative energy sources (i.e., shale oil, coal gasification, solar energy, geothermal energy, nuclear energy), are not sufficient by then to take up any slack. In the short term, though, the policy of developing, producing and reinvesting profits and returned capital to discover additional production (alternative 6) should result in greater U.S. producing capacity than a policy of shutting in production (alternative 5). As discussed in question L–1, if the cost of shutting in production were invested instead in developing new production, it should yield more new oil than the decline from the old production.

From a national security point of view, alternative 6 appears most attractive. To solve our near-term security problem, alternative 6(b) would be preferable to alternative 6(a).

From an environmental point of view, alternatives 1 through 5 would result in greater environmental risk than alternative 6. This is true since tanker transport poses greater environmental risk than offshore operations. (Refer to question K–5 for a fuller discussion.) Alternatives 1 and 5 would result in both the risk of increased tanker operations and the risk resulting from shut-in offshore production. Alternative 6 would pose the least environmental risk.

From an economics point of view, alternatives 1 and 5 would have the highest cost since they would tie up large amounts of non-productive capital. The interest costs of such capital would exceed any potential initial savings from using lower cost foreign oil.

From the point of view of total national energy cost, some savings could be obtained from alternatives 2 through 4. Such savings would be obtained at increased environmental and security risks plus the risk resulting from a deterioration of the U.S. oil industry's domestic technical staffs. The consequences of a deterioration in domestic technical staffs is difficult to assess. Technical capabilities would remain due to overseas requirements, but local knowledge and the number of technical personnel would diminish, making later expansion more difficult.

Alternatives 2 through 4 are attractive economically only because foreign oil is less expensive than domestic crude. If foreign oil prices increase to the U.S. price (which is conceivable), then there would be no consumer advantage to these alternatives.

From an investment point of view, alternative 6 is superior. Presently, the OSC represents our most attractive domestic exploration prospects. Investment to develop our best prospects (the OCS), represents our most efficient use of capital.

Question J–6. What contingency plans and cooperative arrangements have been effected by industry regarding accidents in offshore oil and gas operations? How would these affect response time, total cost and environmental impact? Are further measures desirable or required?

The oil industry has formed cooperative groups to pool equipment and resources and has prepared emergency contingency plans for combating oil spills in all major port areas and offshore producing areas. The various groups were organized to allow rapid mobilization of all available resources to combat any spill. Rapid response using all such resources should allow most effective containment with minimum environmental impact.

The National Oil and Hazardous Substances Pollution Contingency Plan, prepared at the direction of the 91st Congress and PL 91–224, provides a mechanism for coördinating government response to a spill of oil or hazardous polluting substance. The policy of the Federal Government is to respond to those spills in which cleanup is required and in which adequate action is not being taken by the responsible party or other entity. The President, in section 4(a), Executive Order 11548, July 22, 1970, delegated authority and responsibility to the Council on Environmental Quality to carry out subsection (c)(2) of Section 11 of the Federal Water Pollution Control Act, as amended, (33 USC 1151, et seq.).

Primary and Advisory Federal Agencies have been designated and assigned specific duties and responsibilities under the Contingency Plan. A National Response Center, a National Response Team, and Regional Response Teams have been established as set forth in the Contingency Plan. For spill response activities, Federal on-scene coordination will be accomplished through a single, predesignated agent, the On-Scene Coordinator. The Office of Emergency Preparedness has been designated as an advisory Federal Agency. It will maintain an awareness of each pollution incident but will have no direct responsibility unless a request is received from a Governor of a State for a major disaster declaration. If the President declares that a pollution spill constitutes a major disaster under PL 91–606, the Director, OEP, will provide coordination and direction of the Federal response in accordance with OEP policies and procedures.

The industry groups appear capable of handling most accidents without major governmental assistance. However, technology is not presently available to contain major oil spills under conditions of strong currents or heavy seas. Much research is needed on containment and recovery methods at sea and a considerable effort is under way. Current efforts must be continued and additional funds allocated for oil spill control research efforts. This is an appropriate area for joint industry-government effort.

The most effective method to control oil spills is to prevent them. Since the Santa Barbara spill, the U.S.G.S. has significantly tightened regulations concerning offshore development and production activities to minimize future spills. Since offshore oil and gas operations have not been a major source of pollution (an investigation by the Dillingham Corporation for the API has shown that the large majority of past major spills resulted from tanker operations), the revised regulations appear adequate, provided they are properly enforced.

In addition to creating cooperatives to respond to any oil spill, the oil companies have critically reviewed their safety procedures to prevent or minimize future accidents. The high cost of offshore accidents, both economically and politically, was driven home by the Santa Barbara spill and two more recent accidents on the Gulf Coast O.C.S. Such reviews have resulted in a number of procedural and design changes that should reduce the likelihood of future accidents.

Question K–5. If a short-term (two-year) or long-term (five- to ten-year) moratorium were established and all OCS operations were suspended:

(a) From what probable alternative source would petroleum be filled?

(b) To what extent, if any, would these alternatives reduce the risk of coastline oil pollution?

(c) What new environmental risks would be associated with alternative sources of supply?

(*a*) The only alternative sources of energy readily available at present to replace OCS oil and gas are additional crude oil imports and limited volumes of high-sulphur U.S. coal. We have essentially no existing shut-in domestic oil or gas capacity remaining to make up any shortfall resulting from suspension of present OCS oil and gas operations. Long development lead times will prevent rapid development of additional onshore supplies or alternative energy resources such as shale oil, western coal, atomic energy, etc.

Use of high-sulphur coals are presentely limited by environmental restrictions and coal desulphurization or stack gas cleanup technology are not presently available to allow significant increases in coal usage.

Presently, low-sulphur crudes are in tight supply in the world market. The sudden removal of in excess of one million barrels per day low-sulphur OCS crude from the market would likely result in supply shortage and an immediate and significant price increase in foreign low-sulphur crudes.

High-sulphur crudes can be desulpherized using existing technology. However, existing desulphurization facilities would not be adequate to handle the increased demand and about two years lead-time would be required to construct necessary additional facilities. Desulphurization is costly and is not without its own environmental impact. Consequently, the availability of large volumes of high-sulphur crude would not prevent price increases of low-sulphur crude—unless the U.S. was willing to materially ease its sulphur restrictions.

(*b*) Importing foreign crude oil to replace shut-in OCS production would increase, not reduce, the risk of coastline oil pollution. The large majority of past oil spills have been from tanker operations, not oil and gas operation. If the goal is to reduce pollution, a trade of a relative low-pollution risk (oil and gas operations) for a high-pollution risk (tanker operations) is not logical.

Further, declaring a moratorium on OCS operations will neither eliminate nor materially reduce the risk of pollution from existing oil and gas wells on the OCS. The principal danger of accidental spills from producing wells results from accidental collisions with shipping, damage during hurricanes, or from corrosion of casing, well equipment, or flow lines. These risks will continue whether the wells are producing, or shutin. In fact, extending the life of the wells and total exposure time by temporarily shutting them in during a moratorium period would increase the total risk of pollution during the life of the wells.

The danger of pollution from existing OCS wells could be significantly reduced during a moratorium period only by temporarily abandoning all wells (i.e., setting bottom hole plugs to isolate all producing zones from the wellhead). This could be accomplished only at high cost and at increased environmental risk during the time period when the wells are reworked to remove the plugs and return them to production.

(*c*) New environmental risks associated with alternative sources of supply would be the increased risk of oil spills resulting from significant increases in oil tanker activity.

Other Comments.—In our opinion, a moratorium on existing OCS operations would have no merit from an economic, environmental, conservation or national security point of view. We strongly recommend that any consideration of such a policy be completely rejected.

The unfavorable economic and environmental considerations were discussed above. A moratorium would also be detrimental to good conservation practice since shutting in production from reservoirs undergoing pressure maintenance or secondary recovery operations would lead to reduced oil recovery in most cases.

Shutting in producing wells on the OCS would reduce industry cash flow by approximately $1 billion per year. A reduced cash flow of this magnitude would not only significantly reduce the amount of returned capital available for reinvestment, but the reduced earnings and cash flow would materially reduce the ability of the industry to raise additional capital through borrowings (bonds or debentures) or by the sale of equity ownership (stock). With a crippled industry unable to raise the large amounts of capital that will be required to meet our future energy requirements, we could expect to become rapidly and increasingly dependent upon foreign energy supplies to the detriment of our national security.

Question L-1. What consideration has been or should be given to development of OCS tracts and holding production in ready reserve in the event of disruptions in foreign or other sources of supply?

Little consideration has been given to this alternative since it will not materially improve our ability to respond to a disruption in foreign supply, and it can only be implemented at high cost. The vital consideration during a supply disruption is our total production capabiltiy, not just our shut-in capacity. Shutting in a field will not increase our total production capacity.

There would appear to be some gain with time in shutting in a field since the production capacity of a producing field will decline while that of a shut-in field will remain constant. However, we cannot expect a producer to shut in a field without some compensation for the income he will forgo. If, instead of making such a payment to a producer to shut-in production, the Government were to invest it to explore for and develop additional oil ,the increased production would likely equal, or exceed, the loss of productivity from the producing field. Thus, for an equivalent expenditure a greater total capacity could likely be obtained by direct exploration. rather than by making payments for shut-in production.

The Department of Interior has estimated exploration and development costs on the OCS to be 92¢/bbl. If pipeline and interest charges are added, the total investment by the time a field is ready to produce would be about $1.00/bbl. (This assumes no lease bonus payment.)

The minimum return on capital that an oil company would likely consider for producing operations would be about 12%. If we assume that a 100,000,000-barrel field is discovered and developed at a total cost of $100,000,000, an amortization payment of $12,000,000 per year would be required to compensate the company for deferring production. In addition, there will be some expense for maintaining the wells while shut in. Period inspection and corrosion controls will have to be maintained and company overhead costs will be nearly as high with wells shut in as when the wells are producing. Yearly charges of

$3,000,000 for maintenance and overhead would not be unreasonable. Consequently, we could expect a cost of at least 15% of investment per year to compensate the company for the shut-in production.

Actual payment to the company would have to exceed this amount to allow for taxes. However, since the Government would recover the tax payments, the net yearly cost to the Government would be about 15% of the total investment. If, instead of making such a payment, the Government were to invest an equivalent amount in new exploration and development, additional reserves equal to 15% of the initial reserves could be developed although this percentage would decrease with time as exploration costs increase. Since this would most likely equal, or slightly exceed the average decline rate resulting from production of a field, at any time (within a short-range time period of 10–15 years), the production from new discoveries should exceed, or in later years, nearly equal, the decline from the producing 100,000,000-barrel field. Total capacity (producing and shut-in) should be as high, or higher, from producing the field and investing in new fields, as would be obtained from shutting in the field. Thus, there would appear to be little productivity benefit from shutting in the OCS.

In addition to the high cost, any policy that shuts in, or delays, production from the OCS will result in increased foreign imports. With increased tanker traffic, the environmental risk would be increased.

On balance, a policy of shutting in new OCS development, to hold it as a ready reserve, would appear to have a high economic cost, increase our environmental risk, and provide no benefit in meeting future supply disruptions.

STATEMENT SUBMITTED BY THE ENVIRONMENTAL PROTECTION AGENCY

ENVIRONMENTAL PROTECTION AGENCY,
OFFICE OF THE ADMINISTRATOR,
Washington, D.C., May 17, 1972.

Hon. HENRY M. JACKSON,
Chairman, Senate Interior and Insular Affairs Committee,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: The Environmental Protection Agency appreciates this opportunity to comment on certain aspects of the administration of the Outer Continental Shelf under the Outer Continental Shelf Lands Act of 1953 and the National Environmental Policy Act of 1969.

We are today witnessing two converging national trends. One is that of increasing demand within the United States for energy and the attendant necessity to develop energy resources. The other is the broad recognition by both the general public and the Legislature of the need for environmental protection of all resources in the United States. The second relates to both preservation of our national endowment, and amelioration of problems caused by airborne and waterborne pollutants of all types. The Environmental Protection Agency is, therefore, keenly aware of the dual necessities of protecting the natural environment and of developing those forms of fuel which are relatively clean.

Many of the questions posed by the Committee are beyond the primary responsibility of the Environmental Protection Agency and can be better addressed by those Agencies with primary jurisdiction. We submit comments on those areas in which we have knowledge or experience.

F. Lease Administration

2. What measures (including in-house and consultant studies underway or recently completed) have the Federal agencies taken or planned regarding improvement of OCS Administration?

The Environmental Protection Agency and the U.S. Geological Survey have agreed, with the assistance of the U.S. Coast Guard and other State and Federal agencies, to formulate a special contingency plan for the Santa Barbara Channel area. This plan would incorporate existing contingency plans (U.S. Coast Guard and EPA Regional plans, Clean Seas [the industry cooperative] and individual lessees' contingency plans). This action was deemed necessary because of the intensity of oil development in the area, because of hazards in development (due to water depth and geological structure of the reservoir) and because of the unique natural environment of the Santa Barbara Channel, the Channel Islands, and the adjacent mainland.

G. *Jurisdictional issues*

4. What should the role of State government be with respect to Federal decision-making concerning (c) environmetnal regulations on OCS lands bordering the States' jurisdiction?

Section 11 of the Federal Water Quality Improvement Act of 1970 applies to "navigable waters" of the United States. These include offshore waters out to the three mile limit from shore which are under State jurisdiction. At present, discharges of oil in those waters are not permitted if they violate the amount of oil deemed to be harmful by 40 CFR 110. (40 CFR 10 prohibits discharges which violate State water quality standards or cause a sheen, film, or discoloration of surface waters, or an emulsion or sludge below the surface of the water). The Department of the Interior leases mineral rights and supervises the leases on the OCS. In case of a spill incident, the U.S. Geological Survey is the on-scene Federal coordinator on the rig and for waters within a circle having a radius of 500 meters around the rig. The Coast Guard has jurisdiction beyond this circumference. The Environmetnal Protection Agency participates in OCS administration indirectly by devising and evaluating preventative regulations in cooperation with the Geological Survey. EPA is the lead Agency in determining the acceptability of control measures and is inovlved in assessing environmental damage due to spilled oil on the OCS.

Discharges permitted from normal operations of production facilities on OCS lands on the Gulf Coast are not to exceed 100 ppm of oil in water (design 50 ppm); such discharges on OCS lands offshore California may not exceed 50 ppm. This could be in excess of the "harmful discharge" standard applied in navigable waters. Thus there is need for coordination not only between State and Federal governments, but within the various jurisdictions of the Federal government. Areas where State-Federal cooperation are needed include contingency planning, prevention planning, oil spill reporting and monitoring. In addition to coordination in planning efforts, when a spill incident occurs which violates or threatens to violate the water quality standards of a State, the State should be brought into the decision-making process concerning cleanup efforts. Attention should be given to State priorities for protection and the methods of cleanup and control to be used on a given area.

I. National environmental policy act and the OCS

1. In view of the recent Louisiana offshore sale court decision, what changes and procedures, if any, do the Federal agencies contemplate to satisfy NEPA environmental impact statement requirements?

As already stated by the U.S. Department with the requirements of NEPA as interpreted by the Court of Appeals decision (Natural Resources Defense Council, Inc., *et al.*, v. Rogers C. B. Morton, January 13, 1972).

As Federal agencies gain more experience with the preparation of environmental impact statements, those statements improve in quality and scope. A case in point is the series of environmental statements prepared in connection with Outer Continental Shelf lease sales. The more recent OCS environmental statements have incorporated a risk priority rating system to differentiate the risk involved in the several leases considered for sale. Although this risk rating system is in its early stages of development, it represents the beginning of a valuable analytical technique for improved environmental management.

We look forward to further refinement of this system as an integral part of the OCS decisionmaking process.

J. Environmental protection

1. What are the nature and magnitude of the environmental risks and problems related to OCS oil and gas development in:

(a) Geophysical exploration: Exploratory operations, such as seismic surveys, have little permanent effect on the marine environment. The greatest effect during this phase comes from vessels used to conduct such surveys. Abuses in disposal of trash, bilge waste, and other pollutants can originate with such ships as they can with all vessels. The impact of this type pollutant depends largely on the length of time the vessel or drilling rig is in one location, and the attention paid to housekeeping details upon the ship itself.

In addition, Geological Survey regulations provide safeguard necessary to pollution free core-drilling operations where permitted during geological exploration.

(b) Drilling and production: Oil from Outer Continental Shelf drilling and production operations enters the marine environment in four ways: (1) From major accidents and blowouts which take place during drilling or normal production maintenance activities. (Although such accidents have been relatively few, their impact may be severe). (2) From a multitude of small daily oil spills from producing platforms. (3) From discharge of oily brine as a part of normal operations. (4) From the discharge of cuttings and drilling fluids during exploration and production drilling operations.

The several large spills which have occurred in the last few years have largely been failures due to human error and equipment failure. The risk of such spills and the environment damage cannot be totally eliminated. It may be lessened however through technological development, improved operating procedures, and resource management which would withhold or postpone leasing of OCS tracts in proximity of other valuable or unique natural resources. Small daily spills and chronic oil pollution from normal operating procedures is of equal concern. Damage to the marine ecosystem from these sources, although not easily recognizable, may in the long run be more severe than that from the larger spills. The link between laboratory tests establishing the toxicity of certain chemical compounds of crude oil to marine life and the long-term impact of chronic pollution is not well known. More research in this area is vitally needed.

(c) Undersea pipelines: Undersea pipeline construction can affect the marine ecosystem through bottom disturbance and turbidity. This effect is of a tempory nature. Although major public attention has been focused on blowout incidents and attendant pollution on the OCS, major pollution has occurred in the past from pipeline failures and breaks.

4. What follow-up action was taken by Interior, Environmental Protection Agency, Coast Guard, and other Federal agencies after each OCS mishap and what interagency agreements and plans, related to coordinated Federal handling of any future OCS mishaps, have been made as a result of these experiences?

(A) Subsequent to the January 1969, Santa Barbara oil well blowout, revision of the National Contingency plan was initiated to clarify agency roles. Also representatives of the Federal Water Pollution Control Administration (predecessor of Office of Water Programs, EPA) worked very closely with USGS to revise OCS regulations. New, stronger, regulations were issued by USGS in August 1969.

(B) Early in 1971, after the Chevron oil well blowout off the Louisiana Coast, another revision of the National Contingency Plan was begun. Differences between the USCG and USGS regarding response operations on OCS oil rig spills were negotiated and a memorandum of understanding between the Department of the Interior and the Department of Transportation was signed on August 6, 1971. This memorandum of understanding details specific authority and responsibilities between the two departments for actions under the National Oil and Hazardous Substances Pollution Contingency Plan.

(C) EPA, Region IX, USCG, USGS, and the State of California agencies are developing a joint contingency plan for Federal operations on the OCS offshore California. When completed, this plan will include guidelines not only for responding to spills, but also will address permits and other regulatory provisions.

5. What quantitative information is available about the total costs of past mishaps on the OCS, including oil and gas lost, private and government clean up costs, loss of fish and wildlife, damage to tourism, reduced property damage, and administrative costs?

The bulk of EPA's information on mishaps on the OCS was collected during the explosion and fire on Shell platform "B" of December 1970 through April 1971, in the Gulf of Mexico.

EPA estimates that from 95,000 to 130,000 barrels of oil entered the water, 450,000 to 600,000 barrels of oil and an unestimated amount of gas were consumed by fire, and 21,000 barrels of oil were recovered during cleanup operations.

Biological assessments of the open ocean are very difficult to make under any circumstance. The absence of background data compounds assessment problems. Evidence of hydrocarbons was found in water and in organisms adjacent to the platform, but without a pre-fire biological survey of the site, it is not possible to be sure of the origin.

The Santa Barbara blowout, which occurred on January 28, 1969, at an offshore drilling platform approximately six miles southeast of Santa Barbara in 190 feet of water, received extensive public notice. A number of scientific investigations, both government and nongovernment, were conducted which examined the events surrounding the well blowout as well as the environmental consequences.

Conservative U.S. Geological Survey estimates stated that after 100 days the cumulative oil spilled was at least 77,000 barrels. The resultant oil slick covered 500 square miles when at its maximum extent. Cleanup activities concentrated on the shore including beaches and rocky areas. The cleanup program was one of the most extensive short efforts ever undertaken.

A review of the biological studies reveals limited adverse short-term effects that can be directly attributed to the oil spill.

Sea birds were the most visibly impacted animals with an estimated 3,600 birds lost from oil effects. Sea mammals were observed coated with oil but no mortality or short-term effects were noted. The Santa Barbara area is affected by natural oil seeps which conceivably could either render the *in situ* biology more oil tolerant or contribute to a predominance of biological species whose local varieties are more oil tolerant than is usual for the species.

6. What contingency plans and cooperative arrangements have been effected by industry regarding accidents in offshore oil and gas operations? How would these affect response time, total cost, and environmental impact? Are further measures desirable or required?

Both the California and the Louisiana OCS operators have existing cooperative arrangements for cleanup of oil spills. In the Louisiana coastal area, the Offshore Operators' Committee has, since the Chevron and Shell oil rig fires, significantly improved its capabilities. A company called Clean Seas, Inc. has been formed by the companies operating in the Santa Barbara Channel for the purpose of cleaning up oil spills. Generally the existence of organizations such as those listed above results in reduction in response time, cleanup costs, and environmental damage. No quantitative data are available for comparative analyses.

7. What additional geological, biological, engineering or other information is necessary with regard to improving the environmental safety aspects of offshore oil and gas operations? Is there research that ought to be completed before any further offshore leasing? Are there specific instances or areas in which leasing should be postponed pending completion of further studies? What time effort and costs would be involved in this research?

The environmental impact of any particular oil pollution incident is a function of a variety of factors:

a. Nature and quantity of oil released.
b. Pattern of release over time.
c. Geographical location and topography.
d. Environmentally determined patterns and rates of transport, dispersion, and degradation.
e. Vulnerability of exposed biota.
f. Temperature and climate.
g. Transporting mechanisms including ice.

Because of variable oceanic conditions and differing uses of the sea in different areas, the potential consequences of oil spillage can be highly variable.

In order to assess the environmental impact for any given region, good knowledge of the factors listed above would be necessary at a minimum. In addition, basic information is needed on the rates determining processes of bacterial degradation of oil, on the degradation products formed, and on the dispersal and effect of these products within the water column.

In colder climates lower species diversity exists at each trophic level, and therefore there is greater potential adverse impact from oil pollution than in warmer regions. Furthermore, degradation of oil is temperature dependent. New leasing should be postponed in the temperate waters off the northeastern coast of the United States as well as in the Arctic until the consequences of major spills—either acute or chronic—have been clarified.

A major part of the necessary fate research on physical processes would be to determine directions and rate of movement of the crude oil and its degradation products, and on the degradation processes as a function of bacterial populations and temperature. Corollary research is needed on the degradation products formed, their persistence, mutagencity, carcinogenicity, and toxicity under the environmental conditions of the site. The environmental studies for each region are roughly estimated to cost $250,000 per year over five years for physical process, $500,000 per year over five years for biological baselines, and $2,000,000 for degradation studies. Comparable research efforts for the Arctic region can be expected to cost twice as much. Toxicological, geological, and engineering research, including research on oil spills and cleanup technology, should be considered in addition to the environmental work.

8. What is the state of scientific knowledge on the effect of oil spills on fish and wildlife and the marine environment? What is the level of Federal funding for research and development in this area? Are there research opportunities which are not being pursued for lack of funding?

Comparatively little work has been done on the toxicity of oil to marine organisms. Different kinds of oil are made up of different mixtures of many compounds. Since oil is not miscible with water, a variety of techniques have been used in toxicity research which are not necessarily comparable. Oil and water can mix as an emulsion, oil may float on the surface, or various hot extracts of oil can be added to test jars. It follows that there are several different methods to calculate the test concentrations.

Some of the difficulties relating to differences in measuring techniques were resolved in 1970 when staff at the National Marine Water Quality Labaratory, Environmental Protection Agency, West Kingston, Rhode Island, defined bioassay procedures for oil and oil dispersants. Beyond this initial work, little has been done. In February, 1971, that laboratory was instructed to reduce its level of effort on oil effects in favor of the higher priority items such as pesticides and heavy metals.

Almost all of the past extramural grant and contract work, as well as most of the literature in general, concerns surveys of areas *after* oil spills. This type of work rarely produces data which can be used to determine water quality standards.

At the present time, research on oil pollution effects is being carried out by the Office of Research within the Environmental Protection Agency, in its Ecological Effects Branch of the Processes and Effects Division, and in the Agriculture and Marine Pollution Control Section of the Technology Research Division. The figures of FY 71, 72, and 73 are as follows:

	Processes and effects division in-house	Processes and effects division grants and contracts	Technology research division grants and contracts
Fiscal year:			
1971	300,000	163,377	140,000
1972	153,000	157,168	500,000
1973	75,000	60,000	750,000

A continuing research effort is needed to determine the effect of various oils, oil fractions (and oil dispersants on marine organisms and ecosystems. Scientific knowledge of the marine environment is at a nascent point. Generation of such knowledge is prerequisite to optimization of benefits to be obtained from the resources of the sea. Man's activities can be highly disruptive or destructive to the natural systems of the earth, but they need not be. To minimize long-term adverse impacts of marine exploitation, development of an adequate data base and an understanding of that data is necessary. These are primary goals of the Environmental Protection Agency's research program.

Sincerely yours,

WILLIAM D. RUCKELSHAUS,
Administrator.

STATEMENT SUBMITTED BY THE DEPARTMENT OF COMMERCE

GENERAL COUNSEL OF THE DEPARTMENT OF COMMERCE,
Washington, D.C., June 2, 1972.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: This is in reply to your letters of March 8 to Dr. Robert M. White, Administrator of the National Oceanic and Atmospheric Administration and Assistant Secretary for Maritime Affairs Gibson, requesting that they reply to a set of "Questions and Policy Issues Related to Oversight Hearings on the Administration of the Outer Continental Shelf Lands Act".

Enclosed are their answers to those of the questions which relate to the activities of the Department of Commerce. Pursuant to your request, these responses were coordinated with other federal agencies concerned.

Sincererly,

WILLIAM N. LETSON,
General Counsel.

Enclosures.

MARITIME ADMINISTRATION REPORT ON QUESTIONS AND POLICY ISSUES RELATED TO OVERSIGHT HEARINGS ON THE ADMINISTRATION OF THE OUTER CONTINENTAL SHELF LANDS ACT

G. JURISDICTIONAL ISSUES

2. "Provide a summary of pending proposals for offshore terminals, supertanker facilities, offshore nuclear facilities, and other developmental projects which in whole or in part would be located on the OCS".

Offshore Deep Water Terminals

Economic and environmental factors underly U.S. government and industry studies to determine the need for the construction of offshore, deep water port facilities to accommodate the larger bulk carriers. The need for these facilities, their environmental effects, their locations, their cost, their design, who could construct and pay for them are questions currently under intensive study by the Maritime Administration and by other interests in both the public and private sectors. Because of the importance of deep water terminals in our domestic and foreign commerce, thorough coordination with all interested parties is essential in pursuing these study efforts.

The problem of the accomodation of supertankers in U.S. ports is accentuated by the fact that there are 700 deep draft ships of over 100,000 tons deadweight throughout the world in service, under construction and on order that cannot enter U.S. ports. Of this total, approximately 400 are now in operation and 300 are under construction and on order. By 1974, it is estimated that the world fleet of bulk cargo carriers in service over 100,000 DWT will number approximately 800, of which over 400 will be in excess of 200,000 DWT.

The economies of larger tanker and bulk carrier transportation have already given rise to over 50 foreign port facilities in operation, under construction, or planned capable of handling 200,000 ton bulk vessels and larger. The U.S. remains the only exception among the world's major industrial nations who has not provided support facilities to handle these giant bulk carriers. Two existing port areas in the U.S., Long Beach and Puget Sound are the only ones that can provide sufficient depth to accommodate vessels in the range of 120,000 to 250,000 DWT but still lack physical facilities.

MarAd Sponsored Studies

The Maritime Administration is presently studying, under contract to Paul Soros Associates, Inc., the economic, technical and environmental feasibility of offshore, multi-purpose terminal facilities with regional service capability as a means to overcome the present bulk vessel size limitations imposed by inadequate channel depth. It will review commodity flows suitable for super-size bulk carriers, and consider sites on all three U.S. coasts. It will focus primarily on exploring ways to reduce the construction and operating costs of such facilities by identifying advanced technological innovations, including those which may be considered beyond the "state-of-the-art", and expanding the range of potential users. Major emphasis will be placed on designing terminal systems which would be substantially free of oil spill hazards. Completion of this study is scheduled for May 1972.

Corps of Engineers Sponsored Studies

In the conduct of its responsibilities for investigating harbor improvement needs, the Army Corps of Engineers has two major research studies in progress. The first, with A. D. Little, Inc., involves a study of Foreign Deep Water Port Developments. The purpose of this study is to make an interpretive analysis of selected foreign deep water harbors and offshore terminals where the experience would be relevant to the U.S. domestic situation and to present alternatives for the benefit of U.S. policy-makers. This study was completed in December 1971.

For reference, see Institute for Water Resources Report 71–11. The second study with Robert Nathan Associates will seek to determine U.S. port needs, including engineering, economic, and environmental criteria for assessment, analysis of developing alternatives, decision factors for port planning, and critical issues for further analysis. This study will be completed by June 1972.

CEQ Supertanker Study

While both the Corps of Engineers and MarAd's studies will give some attention to the environmental and pollution factors involved, none of them will focus directly on this question. Recognizing that there is vital need to obtain as clear an assessment of the environmental problems involved in deep water port development as there is of the economic benefits, the Council of Environmental Quality has convened a study to identify the probable environmental effects of using supertankers in U.S. foreign trade. Specifically this study will examine potential location/facility alternatives for receiving oil from seaborne transport and evaluate each alternative in terms of its probable amount of oil pollution, environmental impacts, including costs related to those impacts and its other economic costs. The primary product will be a ranking of alternative location/facilities by environmental desirability. Against this ranking, the study will array projected costs—environmental and otherwise—for each alternative. The result is expected to produce a matrix which decision-makers can use to pinpoint the various trade-offs involved in choosing alternatives.

Locally-Sponsored Research Studies

One unexpected result of the American Association of Port Authorities National Channel Capability Study was that it evidently initiated some serious thinking by certain U.S. ports about the supership program and its resulting port requirements. Subsequent to completion of this three year study and independent of it, locally-sponsored, public resolutions were approved by Congress, authorizing the Corps of Engineers to conduct regional port development studies off the Texas, Louisiana, and Alabama Gulf Coast, but limited to the feasibility of deep water ports to accommodate bulk superships. In lieu of three separate studies, Congress subsequently has authorized the Corps of Engineers to combine the resolutions into one comprehensive investigation of the entire Gulf Coast area between Brownsville, Texas and Tampa, Florida.

Establishment of the goals and guidelines for a feasibility study of an offshore port facility off the Texas Gulf Coast has been completed by the Industrial Economics Research Division of Texas A&M University. This project was undertaken for the South Texas Regional Export Expansion Council and financed jointly by the Ports of Galveston, Freeport and Port Arthur and the Sea Grant program of the National Science Foundation. The purpose of this effort was to identify what in-depth studies would be needed in the areas of ecology, economics, engineering, legal, site selection, traffic, etc. to determine if there is a need to accommodate the supertanker on the Texas Coast. The results of this study will serve as a beneficial base for the forthcoming Corps of Engineers regional port study of the Gulf Coast.

On the West Coast the Corps of Engineers, for several years, has had Congressional authority to accomplish regional port studies in the San Francisco and Los Angeles areas. Work on the San Francisco Bay study is now funded and getting underway. Efforts are underway to seek support to fund and begin work on the Los Angeles/Long Beach study.

On the Atlantic Coast, the Delaware River port interests elected through Congressional approval to pursue a Corps study confined to the feasibility of deep water facilities in the Lower Bay area. At the present time, the Port of New York and Maine are seeking Congressional sponsorship for an Army Engineer study aimed at providing a deep water supertanker facility at a optimum location to transship crude oil to both port areas.

The Corps of Engineers in light of the pressing problems confronting bulk shipping interests in the Northeastern United States now has congressional approval to study the entire North Atlantic region from Maine to Virginia.

Thus, it is contemplated that separate regional deep draft port studies will be funded and initiated for the North Atlantic, Gulf and West Coasts during fiscal year 1972 with completion of interim reports by the latter part of fiscal year 1973.

Private Deep Water Port Development and Environmental Constraints

The major problem restricting offshore port development by private interests, particularly in the North Atlantic, is public opposition stemming from fear of potential environmental damage from accidental oil spills.

For example, in 1969 considerable coastal resident opposition was responsible for stymying a pipeline company proposal to construct two mono-mooring buoy facilities for supertankers in the open sea off New Jersey and Delaware. Several oil company proposals to build port terminals for large tankers in deep water bays off Machiasport, Portland and Searsport, Maine were all stalemated by similar public resistance.

Perhaps the most significant action affecting offshore port development was embodied in a recent coastal zoning law passed by the State of Delaware. This landmark conservation legislation specifically bars not only heavy industry, but also offshore bulk transfer terminals from a defined coastal zone along Delaware's bay and ocean fronts. The immediate impact of this legislation was to thwart construction of a major new refinery complex and two privately proposed, offshore deep draft transfer facilities in Lower Delaware Bay—one for exported coal and another for imported crude oil. If Delaware's coastal zoning legislation sets a precedent which is followed by other coastal states. the implications to the national economy could be far-reaching.

Potential Proposals for Offshore Terminals Investigated by Maritime Administration

In the study by Paul Soros Associates, Inc., referred to above, this agency investigated specific potential sites as described below.

This study has looked at 32 potential sites for deep shaft terminals, on the East, West, and Gulf Coasts, we are now in the conceptual design stage for transshipment terminals in two locations which are on the U.S. Continental shelf outside the 3 mile limit: one off the mouth of Delaware Bay and one off the Texas Gulf Coast. The three other sites under investigation within this study are within the 3 mile limit; they are: (1) a site inside Delaware Bay in a semi-protected area behind Cape May; (2) a site close to the mouth of Southwest Pass of the Mississippi Delta; and (3) a site protected by Sandy Hook in lower New York Bay. The two sites in the OCS are summarized below:

A. *Terminal proposal to the Delaware Transportation Company.*—

Site: 8½ miles east of Cape Henlopen situated between the fairways for shipping entering and leaving Delaware Bay, on the edge of a natural deepwater trench which provides 100 feet of water for tankers while enabling the island and break-water for the terminal to built in only 50 feet of water.

Nominal Capacity: 100 million tons/year, crude oil, expandable in stage 2 to 200 million tons/year.

Berths: Two berths with channel depth of 100′ for supertankers. Eight berths with channel depth of about 40′ for feeder vessels.

Configuration: 150 acre artificial island protected by 12,000′ breakwater, crude oil storage capacity: 2.5 million tons. The design concept envisions future expansion of island and breakwater to accommodate coal and ore.

Safety Features: All storage tanks are surrounded by sand fill to prevent damage, all oil pipes on island are in trenches which drain any spillage to a oily waste storage and processing facility. All oily ballast from supertankers or feeder vessels will be transferred or processed on the island. All tanker and feeder berths will have individual oil spill barriers. All traffic will be under centralized control.

B. *Terminal to be proposed to the Texas Superport Study Group.*—

Site: 13 miles off Cedar Lakes, Southwest of Freeport Texas.

Nominal Capacity: 100 million tons/year crude oil, expandable in stage 2 to 200 million tons/year.

Berths: Two tanker berths with depth of 100′.

Configuration: Steel loading platform protected by breakwater. Crude oil storage is located on shore, all oil transferred by submarine pipeline. The design concept envisions future expansion to accommodate dry bulk cargo and addition of one berth for VLCC and two berths for barges.

Safety Features: All oily ballast from supertankers or feeders will be transferred or processed by a special facility within the terminal. Tanker berths will have individual oil spill barriers. All traffic will be under centralized control.

Consideration of Combining an Offshore Terminal with an Airport

In addition to the above two proposals, this agency has provided FAA with technical comment concerning a jetport project to be located about 5 miles off the Jones Beach area of Long Island.

This facility would be protected by a large breakwater behind which would be berths for supertankers, and a plant for processing LNG which would be located at the north end of the breakwater near an existing submarine pipeline for distributing gas.

The design concept is still tentative with respect to the marine terminal aspects, but a unique feature discussed in the FAA study was to incorporate crude oil holding tanks in the airport or breakwater structure.

Industry Proposals for Offshore Terminals

Free State Pipeline Corporation of Baltimore, Maryland has submitted to the State of Maryland and the U.S. Department of Interior preliminary plans for the construction of an Atlantic Ocean oil tanker unloading platform 25 miles east of Assateague Island. According to information received January 12, 1972, the unloading platform will be connected to land by two 24 to 30 inch pipes running west from the platform to a proposed storage farm of eight tanks located northeast of Berlin, Maryland.

Additional pipelines would be laid northward along the Penn Central Railroad tracks, with crossings at the Chesapeake and Delaware Canal and the Delaware River to refineries in Pennsylvania, Delaware and New Jersey. The lines would feed facilities operated by the Getty, BP, Sun, Mobile, Atlantic-Richfield, Gulf, Texaco, Calso, Hess and Humble Oil companies.

Plans will show the unloading platform linked to two buoys 1,500 feet apart, an intermediate pump station upon a Texas-type platform and the pipelines on the Ocean Floor. These preliminary plans have only recently been received and will face intensive investigation by Federal and State officials.

First State Pipeline Company of Delaware

First State Pipeline Company of Delaware proposed a plan on July 8, 1969 to build two 40-foot buoys off the North Atlantic Coast. One of these large tanker receiving mono-moorings would be constructed seven miles off Monmouth County, New Jersey between Long Branch and Monmouth Beach and the other 15 miles southwest of Cape May, New Jersey.

The mono-mooring buoy systems in these locations could service tankers up to 350,000 DWT with economies of scale that would guarantee substantial transport savings as compared with the present North Atlantic maximum size tanker of 80,000 DWT. The Stations would be anchored by flexible lines and have radar reflectors. The crude oil would be pumped to shore through underwater pipelines and through standard underground pipelines to 11 refineries in the Delaware, New Jersey, and Pennsylvania area. A 1200-foot hose would be connected to each mono-mooring to receive the oil from the super-tankers. The hoses would be equipped with lights and would float on the surface of the water when not in use. The estimated total cost of these oil receiving and pumping stations would be in the $150 million range.

Immediate and strong opposition confronted this project in the summer of 1969. Political and resort industry officials, led by Governor Hughes of New Jersey, violently protested a proposal that could potentially pollute the 120 mile New Jersey shoreline. The New York district office of the Army Corps of Engineers refused to issue a necessary permit to the First State Pipeline Company based on the objections raised by the New Jersey interests over the pollution threat. An appeal was made by First State Pipeline to the Department of Interior and other top Federal agencies. Further arrangements for the plan are said to be still pending.

J. ENVIRONMENTAL PROTECTION

1. What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development?

(*d*) *Tanker Operation*

The environmental risks resulting from tanker operation relate primarily to the potential discharges of oil due to:

(1) The intentional or operational pollution resulting from tank cleaning, deballasting and bilge pumping; and

(2) The accidental or episodic discharges resulting from tanker collision, strandings in the open oceans and restricted port approaches and spills in port due to hose failures, overfill of cargo tanks and malfunctions of the cargo transfer system.

A comprehensive description of the major causes of environmental risks related to tanker operation within the Outer Continental Shelf zone follows:

After discharging cargo at the refinery, a tanker will take sufficient sea water aboard in her cargo tanks to facilitate handling at the berth, to insure proper propeller immersion, and to provide suitable seakeeping characteristics. The amount of ballast that a tanker takes aboard at the unloading terminal is a function of the weather conditions, the distance and route of the ballast voyage, the vessel's lightship weight displacement length-to-depth ratio, and other vessel characteristics. The ballast that is put directly into cargo tanks immediately after cargo discharge, is considered only ballast since it comes into contact with and "mixes" with the oil that adheres to the tank surfaces or rests in shallow puddles at the suction mouths after cargo discharge. This oily ballast must be disposed of prior to the tanker's arrival at its loading port. In order to complete its journey after disposing of the oily ballast, clean ballast, suitable for direct disposal at the loading port must be taken aboard. To accomplish this in the absence of segregated ballast tanks, empty cargo tanks must be washed down to remove the residue oil. These tank washings are pumped overboard and the clean tanks are filled with sea water which can be disposed of at the loading port. The number of tanks washed is a function of the particular vessel's hydrostatic characteristics, the weather, the route, the Owner's desire to periodically clean tanks, etc. On average, this amounts to between one third and two fifths of the vessel's tanks per voyage.

Unless properly controlled, this operation could result in all of the residue oil from the cleaned tanks and approximately 15 percent of the residue oil from the tanks which were initially ballasted at the unloading terminal being pumped overboard.

The amount of oil pollution that could result from this operation on any given voyage is a function of the amount of oil that remains in the tanks after discharge. This number is commonly referred to as clingage. This clingage can average from 0.3 to 0.4 percent of the cargo capacity depending on the type of oil, the stripping capability of the tanker, and the internal structure of the cargo tanks.

As a factual matter, the majority of tankers do not pump the oil residue from their tank cleaning operations directly overboard. Rather, the tank cleaning residue (water and oil) is pumped into a slop tank. Here the mixture is allowed to settle and the water drawn off the bottom so that only oil remains in the tank. This oil is then combined with the next cargo; hence, the term "load-on-top" (L–O–T). If all tankers employed a hundred percent efficient L–O–T system one hundred percent of the time, tank cleaning and deballasting operations would not be a source of oil pollution.

As stated above all tankers especially older ones are not capable of conducting L–O–T operations. Moreover, L–O–T operations as such can cope with only 80 percent of the potential operational pollution arising from tank washings. In addition to discharging oil into the oceans due to tank cleaning operations, tankers contribute to the oil pollution problem through minor leakage, bilge pumping, spills during bunkering operations, spills during cargo handling operations and spills as a result of vessel casualties.

International pollution abatement activities

Considerable work has been conducted on the international level to reduce the environmental risks association with tanker operations.

In order to reduce the amount of oil discharged into the oceans from accidental spills, the Intergovernmental Maritime Consultative Organization (IMCO) has approved an amendment to the 1954 International Convention on Prevention of Pollution of the Seas by Oil limiting the amount of oil outflow resulting from a single casualty. IMCO has also approved standards requiring the installation of deck to shore connections for oily bilge and ballast water discharges on all vessels.

Under the IMCO auspices, nine special studies have been initiated, to be carried out by the member nations to develop practical international standards to be incorporated in the 1973 IMCO Marine Pollution Convention. Of these nine studies the U.S. is the lead country in two, Study I—Segregated Ballast Tankers and Study II—Dual Purpose Collapsible Tanks.

MarAd, working in conjunction with AIMS and the U.S. Coast Guard, has completed Study I. The results of this study evaluate the economic impact on tanker construction and operating costs of 12 tanker designs of varying amounts of segregated ballast. The study has provided data to assess the cost effectiveness of the various design feature in mitigating pollution from operational and accidental causes. The study will provide a viable alternative to meet the primary objective of the 1973 Convention on Marine Pollution, elimination of intentional oily discharges into the ocean by 1975, if possible, but not later than 1980.

(*e*) *Port and processing facilities*

The Soros Study indicates that the construction of a breakwater or island could eliminate from productivity the area of seafloor and volume of water it occupies, but will not endanger any species. An acre of continental shelf and waters produces about 5,000 pounds of fish and shellfish each year having an average market value of $.50 per pound. However, some of this loss will be offset by the fish havens inherent in the voids of rubble mound structures and the surge chambers in caisson type breakwaters or island perimeters—provided the waters are not polluted by terminal operations. The offshore siting is preferable to a riverine or estuarine siting as it will effect fewer species and lesser numbers of biota and will represent a much smaller percentage of the total area of like environment. The offshore structures will however provide nesting sites for birds which will feed on the fin fish.

If the breakwater and island reduce wave action at the shoreline, erosion may be reduced and the alongshore current, denied the driving force of the waves, may slow, allowing a deposition of the suspended sediments with resultant acretion of that portion of the beach. Continued acretion will result in the development of a sand spit, or tombolo, which may ultimately extend to the offshore structure. This acretion will be detrimental to the entire coastline if it occurs at the upstream end of a beach system and thus denies the normal supply of sand to the rest of the coastline, which will then be subject to erosion only.

However, if located at the downstream end, where the sand might otherwise be lost through flow offshore, the acretion will benefit the entire coastline by keeping the sand within the system. In general, if the distance from the shore to the structure is greater than twice the length of the structure, the effect on the shoreline will be minimal. This suggests that a breakwater 2 miles long should be located at least 4 miles offshore if changes in the coastline are to be avoided.

Dredging at the offshore site will not produce any long term effects on the biota. During dredging operations fish will be attracted to the site by the turbulence and will feed upon the new food sources exposed, and on each other. The colonies of benthic fauna removed with the dredged material will be replaced within a few years by new colonies. This is not the case with the dredging of estuarine areas where species are more depth sensitive and some, like oysters, require a bed of shells for their existence. If the area dredged is seaward of the sediment laden alongshore current, siltation will not be a problem, otherwise the increase in depth will cause a reduction in current velocity resulting in the settling and deposition of suspended material.

Any terminal operation presents a potential source of pollutants that can have adverse effect on the biota. The principal pollutants from bulk cargo terminals are oils, acid run-offs from ores, and sewage. The damage will be relative to the toxicity, oxygen consumption, persistence and volume of pollutants to which the biota are exposed. The probability of pollutants being discharged into the sea will depend upon the pollution prevention and control equipment provided at the terminal and the care exercised in its operation.

Oil Terminal Operations

Can result in the loss of oils to the sea through transfer operation accidents, inadvertent discharges of oily bilge or ballast waters, equipment failures, and seepage from pipelines or storage tanks. Fortunately, means are available to minimize the occurrence and volumes of such spills and to effect their clean-up.

The experience of the Milford Haven Oil Terminal, Britain's largest, indicates the potential for oil spills that can be expected at a well equipped, well operated terminal. Milford Haven can accommodate tankers up to 250,000 DWT and has an annual throughput of 41 million tons of crude oil refined products. Through improvement in facilities and operating techniques over the past decade, the spillage rate has been reduced to 0.00004% of the throughput—a present average of 13.5 gallons per day. Of the 55 spills that occurred in 1970, 35 were of less than 80 gallons and only 3 were in excess of 160 gallons.

In comparison, 200 gallons per day were discharged from adjacent refineries in the form of oily process waters, run-off from storage areas and processed ballast water from feeder vessels—all discharged at concentrations well below the 50 ppm allowable limit established by the government. The discharge of oils in treated ballast water can be eliminated by utilizing the dirty ballast water from the feeder vessels as ballast water for the departing ocean tankers which are equipped with oil separating systems, or by constructing the feeder vessels with segregated ballast tanks independent of cargo or fuel oil tanks.

The evidence suggests that an offshore oil terminal would not be prejudicial to the marine environment if it is properly designed, equipped and operated. Means exist to minimize the volumes of accidental spills during transfer operations as shown by the record at Milford Haven. The required engineering expertise and construction techniques exist to build leak-proof storage tanks of non-corroding materials that can resist cracking if subjected to earthquake or unequal settlement. Subsea pipelines can be buried to protect them from damage by storm waves, fishing trawls or ships' anchors and can be equipped with leak detection devices.

The great hazard of major spill due to grounding or collision could be substantially reduced by siting the terminal at a deep water offshore location, preferably remote from any estuary or river, and from the restricted channels and fairways utilized by other smaller vessels. Collision avoidance systems now on the market are capable of automatically plotting the courses of several "targets" simultaneously and predicting probable collisions, and navigation sysems have been developed to guide the ships through deep water access routes.

The Maritime Administration has awarded an R & D contract to T. R. Harris, Inc. to study the requirements for shipboard oily waste collection and treatment systems in port. The study will recommend the facilities, operating criteria and costs for oily waste treatment systems that could be utilized at nine selected bulk cargo terminals. Such facilities would receive and treat dirty ballast waters, oily bilge water, tank cleanings and slops. The final report of the study is scheduled to be completed by November 1972.

To what extent is each of the above (J. Environmental Protection) a matter of:

(a) Chronic waste discharges in water.

(b) Episodic (accidental waste discharges in water.

* * * * * * *

(f) Navigation safety.

The chronic and episodic waste discharges related to the OCS oil and gas development in tanker operation and port and processing facilities have previously been discussed in this report. This portion of the report covers the navigation safety of tanker operation.

Navigation Safety

Navigation safety is one of the most significant aspects in the abatement and control of pollution of the seas from tanker operation. Improved navigational aids, navigating equipment and devices on board, traffic management and training of operating personnel are the basic areas to be considered in the overall question of navigation safety.

In general, aids to navigation include charts, maps, sailing instructions, notices to mariners, light houses, lightships and minor lights, day beacons, fog signals, buoys, marine radio beacons, acoustic beacons, loran, sonar, radar, and all types of ship-to-ship and ship-to-shore communication equipment. Their purpose is to assist mariners find their exact position when at sea, to follow natural or improved channels when in coastal waters, and to avoid collisions with other ships and fixed objects. Marine safety including the installation and maintenance of non-shipboard aids to navigation in U.S. navigable waters is a function of the United States Coast Guard.

Casualties due to collision and stranding can be minimized by providing reasonable controls on vessel movements. These could include positive traffic control, traffic separation schemes and the increased control of vessels carrying specific hazardous commodities.

In the last several decades a variety of electronic aids to navigation have come into common use. These are radio beacons, several type sof loran, sonar, radar, and satellite positioning equipment. Some of these aids have passed through several generations of improvements. Essential elements of the new system include:

(1) Traffic separation lanes in waters leading to the harbor, terminal, or congested area.

(2) A traffic control office with authority to control traffic in the area.

(3) Equipment which includes several types of radars, computers, display elements, and ship-to-shore communications.

In some respects these systems resemble air traffic control systems adapted to marine use.

Improved traffic control systems such as the Harbor Advisory Radar System now being experimented with in the San Francisco area should enable tankers to move through congested areas with less risk of collision. Proposed legislation now pending in the Congress (the Ports and Waterways Safety Act) will give the Coast Guard statutory authority to make these traffic control systems mandatory for certain congested ports.

The recently enacted Vessel Bridge to Bridge Radiotelephone Act (P.L. 92–63) will require vessels to be equipped with direct radiotelephone communications in order to provide a means of exchanging information as to their maneuvering in close proximity.

The Maritime Administration's proposed offshore oil terminal concept, as covered by the Soros Study, would incorporate a radar traffic control system.

Traffic safety is avital consideration in the design of an off-shore oil terminal. If detailed surveillance of all traffic in the vicinity of the terminal is maintained—and if the revealed patterns are extrapolated for short periods into the future—it becomes possible to predict traffic conflicts. If terminal traffic is controlled this prediction can then be employed to avert potentially disastrous accidents. Such surveillance, prediction, and control can be accomplished using existing radar, computer, and display technology, in an appropriate blend of automatic and manual operation.

The key to the system is comprehensive radar monitoring and automatic data processing equipment which provide real time information, including identification of all ships and extrapolation of future traffic conditions based on their present courses. Terminal traffic must be under central control and assigned lanes and speeds, with the adherence to such assignments automatically monitored.

Interaction between man and automatic equipment is achieved by computer generated idsplays which present graphic images of the traffic conditions. They also provide guidance to the viewer, warning of conflicts, and the results of traffic analyses. The displays present traffic in a map format for specific areas within the radar coverage region. Map symbols include key buoys, ships in three size categories, traffic lane center lines, and at an operator's option tags on identified ships, and trails and/or leaders based on past history. The border around the map is reserved for prompting cues to the operator, results of analyses, and function key labels. Satellite displays show other map areas. Ship status displays show identified ships in the system.

Vessels calling regularly at the terminal can be equipped with a combined data/voice link which will permit the deployment of similar displays on board the ships for use by pilots.

In an endeavor to improve the safety in navigating large vessels, the Maritime Administration has the following research contracts under way:

(*a*) advanced conning systems—American Export Isbrandsen Lines

(*b*) evaluation of satellite navigation systems—United States Lines/International Telephone and Telegraph Company

(*c*) develop computer oriented satellite communications employing UHF transmission—Applied Information Industries

(*d*) analysis of future crew skills and manning—Stanwick Corp.

J. ENVIRONMENTAL PROTECTION

8. "What is the state of scientific knowledge on the effect of oil spills on fish and wildlife and the marine environment? What is the level of Federal funding for research and development in this area? Are there research opportunities which are not being pursued for lack of funding"?

The state of scientific knowledge on the effect of oil spills on fish and wildlife and on the marine environment is extremely limited. Knowledge of the fate of oil, after it has disappeared from view at the ocean surface or the fate of the hydrocarbon fallout in the ocean from the atmosphere is very incomplete. The chronic, low level effects of oil exposure on the phytoplankton, the primary marine foods producers, or on other links in the marine food chain are virtually unknown.

The Department of Commerce has recently initiated a joint study on the scientific aspects of oil spills on marine organisms over a 3 year period. This study will be undertaken jointly by the Maritime Administration, National Oceanic and Atmospheric Administration, and the National Bureau of Standards. The objective of the study is to establish a body of hard knowledge and basic data in order to determine, with a high degree of scientific accuracy, the maximum permissible level of oil considered to be harmless to the marine environment. The establishment of this baseline data will permit a rational approach to the formulation of realistic and meaningful standards for permissible oil discharge from ships and policies on the prevention and control of oil discharges. This work will involve an extensive program of laboratory and environmental field studies.

MarAd has been established as the sponsoring agency and will make the results of the study available in a form in which the regulatory bodies may develop policies relating to the prevention and control of oil discharges from ships.

The NBS will conduct tests to develop satisfactory techniques for the identification and quantitative determination of crude oil fractions and specific chemical components. These techniques and developments will aid NOAA/NMFS in its laboratory and field studies for determining the fate and effect of oil discharges.

The environmental consequences of oil pollution from ships is also being dealt with on an international basis. It is one of the nine studies sponsored by the Integrovernmental Maritime Consultative Organization (IMCO) to develop practical alternatives to achieve the goal of complete elimination of oily discharges into the oceans from ships by 1975, if possible, but not later than the end of the decade. Such international standards are being considered for adoption at an International Conference to be held in 1973 on Prevention of Pollution of the Seas by Oil from Ships.

STATEMENT SUBMITTED BY THE DEPARTMENT OF THE ARMY

DEPARTMENT OF THE ARMY,
OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D.C., April 24, 1972.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

DEAR MR. CHAIRMAN: In the absence of the Chief of Engineers, I am responding to your recent letter requesting a report on selected questions and policy issues posed by your Committee.

The shoreward limits of the Outer Continental Shelf are defined by the Outer Continental Shelf Lands Act of 1953 (67 Stat. 462, 43 U.S.C. 1331–1343). Specifically, 43 U.S.C. 1331(a) provides:

The term "Outer Continental Shelf" means all submerged lands lying seaward and outside of the area of lands beneath navigable waters as defined in section 1301 of this title, and of which the subsoil and seabed appertain to the United States and are subject to its jurisdiction and control.

The reference to "section 1301" in the above-quoted provision of the Outer Continental Shelf Lands Act is to the Submerged Lands Act of 1953 (67 Stat. 29, 43 U.S.C. 1301–1315) whereby the United States relinquished to its coastal states its right, title, and interest in and to lands beneath navigable waters as defined by Section 1301 of Title 43, United States Code. The definition of "lands beneath navigable waters" as set forth in 43 U.S.C. 1301 may, for the purposes of this report, be summarized as those lands seaward of the coast line extending to a point three geographical miles into the sea. Two exceptions to this are those lands lying off the coasts of Texas and Florida, and extending into the Gulf of Mexico where it has been determined by the Supreme Court of the United States that the seaward boundary is approximately three marine leagues rather than three geographical miles (*United States v. Louisiana et al*, 363 U.S. 1 (1960);

United States v. Florida et al, 363 U.S. 121 (1960); and *United States v. Louisiana, et al.*, 394 U.S. 1 (1969).

The Outer Continental Shelf Lands Act does not define the seaward limits of the Outer Continental Shelf. The seaward limit is defined, however, by the Convention on the Continental Shelf, to which the United States is a signatory party (U.S. TIAS 5578; 15 UST 471), and which was approved by the United Nations Conference on the Law of the Sea on April 26, 1958 and went into effect on June 10, 1964. Article 1 of the Convention provides:

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.

The term "territorial sea" is defined in Article 1 of the Convention on the Territorial Sea and the Contiguous Zone, to which the United States is a signatory party (U.S. TIAS 5639; 15 UST 1606, 1608), and which was approved by the United Nations Conference on the Law of the Sea in the spring of 1958 and went into effect on September 10, 1964 as follows:

1. The sovereignty of a State extends, beyond its land territory and its internal waters, to a belt of sea adjacent to its coast, described as the territorial sea.
2. This sovereignty is exercised subject to the provisions of these articles and to other rules of international law.

Historically, the United States has claimed the internationally accepted three-geographic-mile limit as its "territorial sea" which has been upheld on numerous occasions by the Supreme Court of the United States (see, e.g., *Cunard v. Mellon*, 262 U.S. 100 (1923)).

The Department of the Army, acting through the Corps of Engineers, exercises broad regulatory authorities over the placing of any structures, or the dredging, filling, alteration, or depositing of refuse in the navigable waters of the United States. The navigable waters of the United States include the waters of the territorial sea.

Under international law, the United States may regulate the erection of fixed structures and artificial islands of the Outer Continental Shelf where such construction would affect the exclusive sovereign rights of the United States to explore and exploit the natural resources of the seabed and subsoil of the Outer Continental Shelf. The Corps of Engineers has been given the authority to regulate such construction under Section 4(f) of the Outer Continental Shelf Lands Act. The regulations adopted pursuant to this statute by the Corps are found at 33 CFR, Section 209.120. These regulations provide for the issuance of permits to erect such structures. The Corps policy on issuance of such permits may be summarized as follows: The decision as to whether or not a permit will be issued is based on the total public interest as reflected by such factors as navigation, fish and wildlife, water quality, economics, conservation, aesthetics, recreation, water supply, flood damage prevention, ecosystems and, in general, the needs and welfare of the people; except that in the case of permits for fixed structures or artificial islands on Outer Continental Shelf lands which are under mineral lease from the Department of the Interior, the decision will be based only upon the effect of the proposed work on navigation and national security.

The readily apparent difference between the criteria used to determine whether a permit will issue on those lands under mineral lease from the Department of the Interior and those lands not under mineral lease may be explained as follows: The Department of the Interior is responsible for the selection of lands on the Outer Continental Shelf for inclusion in the mineral leasing program administered by that Department. Prior to the selection of tracts for leasing, the Department of the Interior evaluates the effect of the leasing program on the total public interest, including environmental concerns. Accordingly, in cases involving applications for permits to erect fixed structures or artificial islands on Outer Continental Shelf lands under such leases, the Corps reviews such work solely from the point of view of the effect on navigation and national security. This policy prevents wasteful duplication of effort and leads to maximization of efficiency and expertise.

For permits other than those involving leased Outer Continental Shelf lands, the procedure for taking into account recreational, fish and wildlife, and other environmental values is as follows: The proposal is circulated to State and Federal agencies having expertise in the matter, their responses are considered and taken into account, public hearings are conducted if appropriate, and finally, an environmental impact statement as required by the National Environmental Policy Act of 1969 is written where the granting of the permit would constitute a major Federal action "significantly affecting the quality of the human environment."

The Corps must defer to the Department of the Interior regarding the Committee's inquiry concerning the procedures used by that Department to evaluate environmental factors and the authority of the Secretary of the Interior with respect to leasing of lands on the Outer Continental Shelf.

The Committee has asked that it be supplied with a summary of pending proposals for offshore terminals, supertanker facilities, offshore nuclear facilities, and other development projects which in whole or in part would be located on the Outer Continental Shelf. The Corps does not maintain a listing of offshore proposals unless the sponsors of such proposals have applied for a permit. To date, no applications have been received and no permits issued for such facilities on the Outer Continental Shelf.

The Corps has not examined the question of whether or not leasing should be postponed pending completion of further general studies and would defer to other agencies having a direct interest in the matter.

Finally, the Corps does not have sufficient information on which to evaluate the state of scientific knowledge on the effect of oil spills on fish and wildlife in all pertinent marine environments. The state of knowledge is understood to be inadequate, especially as it bears on the biological effects of chronic exposure to low concentrations of oil on the marine environment.

I trust the above information will be of use to the Committee on Interior and Insular Affairs.

Sincerely yours,

A. P. Rollins, Jr.,
Major General, USA,
Deputy Chief of Engineers.

STATEMENT SUBMITTED BY THE DEPARTMENT OF TRANSPORTATION

Department of Transportation,
U.S. Coast Guard,
Washington, D.C., May 5, 1972.

Hon. Henry M. Jackson,
Chairman, Committee on Interior and Insular Affairs,
U.S. Senate,
Washington, D.C.

Dear Mr. Chairman: This is in response to your letter of March 9, 1972, in which you invited the Coast Guard to prepare a report to the Senate Interior and Insular Affairs Committee on selected questions and policy issues relating to a review of the administration of the Outer Continental Shelf Lands Act of 1953.

The enclosed report contains responses to the specific questions on which you requested the Coast Guard to comment. We have also responded to addition questions wherein we believed it would assist the Committee in achieving its objectives.

The Office of Management and Budget advises that from the standpoint of the Administration's program, there is no objection to the submission of this report for the consideration of the Committee.

Sincerely,

T. R. Sargent,
Vice Admiral, U.S. Coast Guard, Acting Commandant.

Enclosure: (1) Answers to questions and policy issues related to overview hearings on the Outer Continental Shelf Lands Act.

A. The Present Legal Regime for the Outer Continental Shelf

1. What Federal statutes directly contribute to or constitute the existing legal regime for the management of the resources of the OCS (including relevant Executive Orders or other executive branch policy statements and relevant court decisions)?

The following Conventions and Federal statutes directly contribute to or constitute the existing legal regime for the management of the resources of the OCS (this listing is not exhaustive and other agencies may suggest additional authority).

(*a*) Convention on the Continental Shelf (April 29, 1958, United States June 10, 1964) 15 UST 471, TIAS 5578, 499 UNTS 311;

(*b*) Convention on the Territorial Sea and the Contiguous Zone (April 29, 1958, United States September 10, 1964) 15 UST 1606, TIAS 5639, 516 UNTS 205;

(*c*) Convention on the High Seas (April 29, 1958, United States September 30, 1962) 13 UST 2312, TIAS 5200, 450 UNTS 82;

(*d*) Submerged Lands Act (May 22, 1953) 43 U.S.C. 1301 et seq., 67 Stat. 29;

(*e*) Outer Continental Lands Act (August 7, 1953) 43 U.S.C. 1331 et seq., 67 Stat. 462;

(*f*) 14 U.S.C. 2, 81, 88, 89, 92, 93, and 94:

(*g*) 33 U.S.C. 403 (March 3, 1899) 30 Stat. 1151 (as extended to OCS by 43 USC 1333(f));

(*h*) National Environmental Policy Act (January 1, 1970) 42 U.S.C. 4331 et seq., 83 Stat. 852;

(*i*) Federal Water Pollution Control Act, as amended, 33 U.S.C. 1151 et seq.;

(*j*) Departmetn of Transportation Act (October 15, 1966) 49 U.S.C. 1651 et seq., 80 Stat. 931;

(*k*) Assimilated State laws of twenty-three States insofar as they are applicable and not inconsistent, 43 U.S.C. 1333(a)(2);

(*l*) Various vessel inspection statutes generally keyed to size, propulsion, and nature of operations of the vessels navigating on the OCS;

(*m*) The 1960 Supreme Court decisions extending the boundaries (for purposes of the Submerged Lands Act) of Florida and Texas into the Gulf of Mexico up to three marine leagues (six miles beyond the territorial sea) and within historical boundaries.

2. What, in summary form, is the major goal or purpose of each of these statutes, orders or policy statements (e.g. resource development, oceanographic research, fish and wildlife protection, pollution control, etc.)?

The Submerged Lands Act, 43 U.S.C. 1301 et seq., defines the respective rights of the States and the Federal government as regards lands beneath navigable waters within State boundaries and the resources within these lands.

The Outer Continental Shelf Lands Act, 43 U.S.C. 1331 et seq. (hereinafter OCSLA), prescribes the authority of the Secretary of the Interior to regulate exploration for, or development or removal of deposits of, oil, gas, or other minerals. Authority is designated to the Department in which the Coast Guard is operating to promote safety of life and property on the artificial islands and fixed structures established pursuant to that regulation and to mark those islands and structures for the protection of navigation. 43 U.S.C. 1333(e). The authority of the Secretary of the Army to prevent obstruction to navigation is similarly extended to those islands and structures. 43 U.S.C. 1333(f). The OCSLA is limited by its terms to lands beyond State submerged lands boundaries. 43 U.S.C. 1331(a).

The provisions of title 14 apply in part to the high seas. Coast Guard law enforcement authority and other primary duties and authority are applicable and can reach vessels in these waters engaged in exploration and exploitation of resources of the OCS. 14 U.S.C. 2, 88, 89, 92, 93, & 94. Authority to establish, operate, and maintain aids to navigation applies to waters above the Continental Shelf. 14 U.S.C. 81.

The provisions of 33 U.S.C. 403, extended to the OCS by 43 U.S.C. 1333(f), give the Secretary of the Army authority to prevent obstructions to navigation caused by islands or structures erected pursuant to the OCSLA.

The National Environmental Policy Act 42 U.S.C. 4331 et seq., (hereinafter NEPA) establishes policies and procedures designed to assess and consider the impact of Federal actions on the environment, including the area of the OCS.

By the terms of sections 11 and 12, the Federal Water Pollution Control Act, as amended (hereinafter FWPCA), is applicable to any contiguous zone "established or to be established by the United States under article 24 of the Convention on the Territorial Sea and the Contiguous Zone." Section 11 (33 U.S.C. 1161) deals with control of pollution by oil. However, this section and section 12 (33 U.S.C. 1162), which addresses control of pollution by hazardous substances, are inapplicable to offshore facilities beyond the three mile limit governed by the OCSLA. Section 13 (33 U.S.C. 1163) which deals with control of sewage from vessels, applies only in the navigable waters of the United States, but of course would indirectly reach U.S. vessels serving OCSSLA structures.

The Department of Transportation Act, 49 U.S.C. 1651 et seq., transferred the Coast Guard from the Treasury Department to the Department of Transportation.

As to the assimilated State laws, 43 U.S.C. 1333(a)(2), see our answer to question G.4.

As to the applicability of vessel inspection statutes, title 46 U.S.C., see our answer to questions F.1 and J.1.

The 1960 Supreme Court decisions extended the seaward boundaries of Florida and Texas on the Gulf Coast to up to three marine leagues (but within historical boundaries). These decisions have created some ambiguity with respect to the Federal authority for navigation and other safety purposes between the seaward limit of the territorial sea and the shoreward limits of the other continental shelf.

3. Which entities within which Federal agencies have been assigned OCS responsibilities and what formal and informal coordinating relationships (interagency committee, memoranda of understanding, etc.) exist among these agencies regarding OCS administration?

The Department of Interior conducts the basic lease administration scheme on the OCS. As a part of that responsibility we understand that in recent years certain lease provisions have been included which are directed at the promotion of safety of life, property, and navigation, and protection of the marine environment as those factors might be affected by islands and structures subject to the OCSLA.

The Department of the Army, through the Corps of Engineers, and the Department of Transportation, through the Coast Guard, have generally worked together whenever possible within the relatively narrow context of the OCSLA to promote navigation safety on the OCS. While the Department of Interior cannot exclude areas of the OCS covered by navigation fairways from the leasing program, the Corps of Engineers has advertised that permits for the erection of facilities will generally not be granted in any of the established fairways and only to a limited extent in anchorages (33 CFR 209.135 & 209.138) (see chart, enclosure 1).

The Coast Guard has issued regulations for marking islands and structures subject to the OCSLA (33 SFR 67) and for certain safety requirements thereon (33 SFR 140–146). Authorization to mark structures on the OCS is granted by Coast Guard after approval of the facility by the Corps of Engineers (33 CFR 66.01–30 & 67.01–1(b)) or when a permit application is pending with the Corps for an exploratory operation. Guidelines for marking generally are treated in Commandant Instruction 3264.2 of 9 Mar. 1972. OCSLA structures and islands and underwater completions are treated in paragraphs 10 & 11 of that instruction (enclosure 2).

We are familiar with no other working arrangements, formal or informal, for OCS administration except for a memorandum of understanding between Coast Guard and the Geological Survey regarding the National Oil and Hazardous Substances Pollution Contingency Plan (enclosure 3).

4. What changes in the existing legal regime or Federal organization structure for management of the OCS have been proposed or recommended by Federal advisory committees or by the Administration and what, in summary form, is the purpose of these recommended changes?

The Coast Guard has not made, as yet, any specific recommendations for changes in the existing legal regime or Federal organizational structure for management of the OCS. We have, however, had various matters, primarily of a safety nature, under study within Coast Guard for many years. Our position and substantial concern has been reflected nationally in our long-standing participation in proceedings relative to safety on the OCS conducted by the Coast Guards' National Offshore Operation Industry Advisory Committee to the Marine Safety Council (formerly the Offshore Operations Advisory Panel) and internationally through position papers the Coast Guard has presented to the Intergovernmental Maritime Consultative Organization (IMCO). A copy of a February 1967 discussion of safety aspects of offshore installations in the Gulf of Mexico prepared in Coast Guard is enclosed (enclosure 4). For the most part it represents an accurate picture of the current safety regulation administration and related problems on the OCS, with the exception that procedures to establish the safety zones referred to on page 7 of enclosure 4 have been promulgated by recently-issued regulations.

5. What additional changes in the existing legal regime or Federal organizational structure merit Congressional consideration and review?

We believe that the need for an orderly, comprehensive, and coordinated program to provide for the safety of life and property, and the protection of the marine environment on the continental shelf is at hand. Under such a program, concentrated effort could be directed to specific problem areas dealing with the continental shelf maritime environment. These broad goals should include—

(*a*) the resolution of possible conflicts in use as they relate to such matters as vessel transportation, pipeline transportation, fishing, recreational activities, and fixed and mobile structures on and over the continental shelf.

(*b*) the prevention, reduction or elimination of wrecks, debris, pollutants, and other matter on the continental shelf insofar as they constitute obstructions or impediments to surface or subsurface navigation, including fishing, hazards to life and property, or threats to the marine environment.

(*c*) the establishment of safety standards applicable to all types of structures and devices used on the continental shelf so as to promote reduction of loss of life and to prevent injury to personnel, and property; and

(*d*) the establishment of a program for the protection of the maritime environment similar to that presently being implemented in waters within the territorial sea.

Some statutory authority permitting action to deal with these problems currently exists. Further extensions of United States activity with respect to its nationals poses no legal problems. However, it is otherwise as to significant extensions of control of activity of foreign vessels and citizens. While there is probably still room for additional regulation of the latter within the regime of the Continental Shelf and Contiguous Zone Conventions, the proper course to be taken for comprehensive regulation of foreign activity raises questions of international relations which touch upon the United States posture in the current Law of the Sea negotiations. This way pose a serious dilemma. The discussions in this paper are intended only to describe the safety considerations which must be resolved and no suggestion as to an executive branch position regarding the resolution of the United States international law posture in this area is to be inferred from our suggestions as to necessary additional regulation.

The growth of the offshore mineral mining industry in a relatively short time period is illustrative of the problems to be anticipated in the use of continental shelf environment. In the Gulf of Mexico today, there are over 1,850 installations beyond our territorial waters, many of which interfere to a greater or lesser extent with the more traditional activities conducted in this area such as fishing, transportation, and recreation. The proliferation of these structures made necessary the establishment of fairways so as to provide some measure of unobstructed access to major port areas. The shipping fairways were a compromise measure established in lieu of the IMCO-approved traffic separation lanes, a compromise which resulted from the lack of space between structures for the traffic separation lanes. The vessel traffic is very heavy in that region of the OCS (see 1969 Daily Distribution of Traffic in Gulf of Mexico, enclosure 5). The tankers, as they increase in size, become less maneuverable in these relatively small fairways. Unfortunately, in most instances the action taken has been a reaction to the existing problem rather than anticipatory action to prevent the problem.

We can reasonably expect that other new endeavors will develop, each deserving the safe use of a fair proportion of the environment. Even now the activities conducted on the OCS have created conditions which will impede and obstruct the use of the continental shelf area, particularly in the Gulf of Mexico. The accumulated debris of the offshore mineral mining activity, including wrecked structures and abandoned associated equipment, is distributed over a wide expanse of the continental shelf. This debris may represent a hazard, depending upon location and size, to increasing surface and developing subsurface navigation. It also represents an impediment to fishing activities, particularly trawling. As the activities on our continental shelves multiply, these problems will become more acute, demanding some positive action to regulate the activities and to resolve competition between conflicting activities.

Under any legislative proposal developed to provide comprehensive administration of the OCS, authority should be granted to promulgate and enforce Federal regulations applicable to United States nationals:

(*a*) governing all aspects related to safety of life and property of installations and their equipment erected or located on the continental shelf, except for those fixed structures and artificial islands already subject to the regulatory provisions of the OCSLA;

(*b*) governing the establishment and marking of installations not covered by the OCSLA which are owned or operated by nationals of the United States or which are linked physically to the United States as well as associate matters including the development of vessel traffic control systems of the OCS, the establishment of sealanes and fairways in which installations would be prohibited, and the designation of areas in which the deposit of wrecks and debris would be permitted; and,

(*c*) governing protection of the marine environment similar to Federal authority now exercised within the navigable waters of the United States.

Another appropriate area of possible legislation would encompass authority to allow the Secretary of the Department in which the Coast Guard is operating to take action to remove wrecks or debris on or above the continental shelf, and to recover the cost thereof from the owner.

We are resolving, in conjunction with the Department of State, the need for executive or legislative action which might clearly enunicate a contiguous zone for the purposes of Sections 11 and 12 of the Federal Water Pollution Control Act.

Finally, the possible ambiguity in respect to Federal authority for navigation and other safety purposes off the Gulf coasts of Florida and Texas between the seaward limit of the territorial sea and the historic boundaries of the States should be addressed.

D. Information for Decisionmaking and Management

3. "What are the advantages and disadvantages, from the point of view of maximizing resource development, lease revenues, safety and environmental protection, and from the standpoint of cost, of using the present informational system for identifying promising acreage prior to lease sales compared to: (a) The Federal government conducting its own expanded geological and geophysical surveys, (b) Purchasing such information from private surveyors, (c) Requiring members of the petroleum industry to submit on a confidential basis their exploratory data and resulting assessment, (d) Developing new sources of information, in addition to geological or geophysical information, (e) Any combination of these alternatives?"

Although we are not thoroughly familiar with the details of the present system used to identify promising acreage prior to OCS lease sales, the Coast Guard feels that the lease selection process should give attention to compatibility with the other more traditional uses of the OCS, including transportation, recreation, and fishing. From the point of view of maximizing resource development, and, more particularly, safety and environmental protection it would be advantageous to the decision making process for the Coast Guard to participate more fully relative to navigation and safety matters and pollution abatement efforts on the OCS.

Any applicable regulatory activity on the OCS which could affect navigation, the safety of life and property, or pollution abatement efforts should, as an essential prerequisite, require coordination with the Coast Guard so as to take into account matters such as safety measures in effect, shipping safety fairways, anchorage areas, and contingency plans for controlling and combating oil and other pollutant discharges.

E. Present Decisionmaking and Management Procedures

2. "What is the procedure currently used by the Federal agencies for taking into account recreational fish and wildlife and other environmental values in choosing tracts to be leased?"

While we fully appreciate the necessity of taking into account environmental values, the Coast Guard is concerned with the initial problem of the resolution of the conflict of use of the waters superjacent to the continental shelf. Under the OCSLA priority has apparently been given to the erection of drilling and production platforms over other uses of the same area, principally water transportation and fishing—particularly trawl fishing. The consequences of this in the Gulf of Mexico has been a proliferation of resource development structures without adequate consideration being given to the movement of vessels. The traffic separation schemes of the type approved by IMCO cannot physically be estabilshed in the Gulf off the principal ports because there is insufficient space. The less satisfactory solution of establishing the so-called fairways has been the compromise. We must be sure that on the remaining portion of the Continental Shelf of the U.S., adequate consideration is given to all uses.

While the resource development structures themselves impede surface traffic, especially the operation of the larger vessels, the interference with commercial fishing, particularly trawling, is more from the impediment of the oil exploitation industry left on the seabed. Pipelines are permitted to be laid rather at the whim of the industry with no requirement that the locations be charted or that pipeline corridors be used. Since except for the pipe laid near the foreshore, these pipelines are not trenched or buried, the advent of a storm causes considerable damage. Hurricanes and other severe storms can break and move pipelines laid in fairly deep water. These pipelines, rendered unusable, are not recovered but simply replaced. Storms also wreck a number of structures each year, distributing the debris over the ocean bottom. This wreckage is not removed. Consequently sizable areas of seabed are cluttered with enough debris to discourage or defeat trawling operations.

As to accounting for environmental values in choosing tracts to be leased, the Coast Guard is not familiar with the details of the procedure currently used by other Federal agencies for taking those values into account. However, the Coast Guard does participate in the development of environmental impact statements required by NEPA when offshore sales are proposed. This assistance is generally in the nature of identifying navigational safety fairways that would or could possibly interfere with exploration/exploitation, contingency planning to control and abate pollution, and making recommendations to prevent pollution.

Based on the recent court decision involving the proposed OCS lease sale, the Coast Guard is initiating a change to the 102 statement preparation procedure in order to examine more fully the alternatives to a proposed action.

F. Lease Administration

1. What, in general, are the current procedures for lease supervision and inspection? Are there concrete indications of improved surveillance and compliance over past experience? To what extent has the risk of accidents such as those which occurred near Santa Barbara and offshore Louisiana been reduced, and to what factors are reductions (if any) due?

Although issuance of leases is not the direct responsibility of the Coast Guard, this agency is involved in a number of areas of lease supervision in conjunction with safety and with pollution detection and removal.

Pursuant to the OCSLA the Coast Guard has authority to "promulgate and enforce such reasonable regulations with respect to lights and other warning devices, safety equipment, and other matters relating to the promotion of safety of life and property on the islands and structures. Artificial Islands and Fixed Structures on the Outer Continental Shelf (33 CFR 140–146) were published under that authority. These regulations apply to mobile and built-up platforms used in resource development, lifesaving appliances, fire fighting equipment, and certain special operating requirements. In addition, the Coast Guard has issued regulations to prescribe necessary obstruction lights and fog signals (33 CFR 67).

Although the regulations were issued in 1956 and the Coast Guard began a program of inspections, these inspection efforts were hampered by economic realities, including a shortage of personnel and a lack of sufficient air transportation. By 1962, some 1,300 resource development structures had been inspected in the Gulf of Mexico area. At present there are approximately 1,850 such structures on the OCS and an additional 4,200 located near the coast. The large majority of these structures are unmanned. Because of the aforementioned limitations, the Coast Guard has emphasized the inspection of manned platforms as being the most cost effective alternative, and an attempt is made to board and inspect each manned platform annually. Drilling units of the submersible or semi-submersible type are inspected and certificated as seagoing barges under 46 U.S.C. 395. This inspection provides assurance that the construction and arrangement of these vessels are suitable for the route and service intended while in transit to new locations.

The number and size of mobile bottom bearing and drilling units, which often operate world-wide, has increased. There have been casualties during transit to new drilling sites. As a result of increased concern over their safety it appears appropriate to inspect these craft as seagoing vessels and to issue a certificate of inspection to be valid during transit. In this regard, the Coast Guard has published a proposed change to the Code of Federal Regulations, considered at a Public Hearing held on March 27, 1972.

The Coast Guard is actively involved in many surveillance programs on the OCS or in waters immediately adjacent to the OCS. Routinely, once a week, flights have been made over the critical pollution areas of the U.S. coastline. With the recent addition of six special purpose aircraft, the entire coastline will be surveyed weekly. In addition, frequent pollution patrols are made of harbors and bays. These pollution surveillance flights occasionally are directed to fly over specific areas of the OCS to spot check oil exploration operations. We conduct coastal air borne radiation thermometer flights over large areas of the OCS and seasonal oceanographic cruises are carried out throughout these same waters. In addition, our Offices of Research and Development and of Engineering are developing instrumentation to assist us in the monitoring and surveillance of these waters. Of particular importance will be the development of sensors specifically for pollution control purposes.

The Coast Guard also enforces other laws and treaties in several areas overlapping the OCS, particularly the statutes that prohibit foreign fishing within twelve miles of the coast. We routinely conduct surface and air patrols for these purposes. In order to carry out various missions with optimal utilization of resources, the Coast Guard has involved its personnel in a multi-mission approach to planning and operation. Thus aircraft or ships often conduct pollution surveillance activities as an adjunct to many other missions. Each time a Coast Guard vessel/aircraft traverses the OCS we are, in effect, also conducting pollution surveillance to the degree that operations permit when such a transit is not specifically for pollution surveillance.

F. Lease Administration

2. What measures (including in-house and consultant studies under way or recently completed) have the Federal agencies taken or planned regarding improvement of OCS administration?

See our answer and materials in response to question A.4.

G. Jurisdictional Issues

1. What jurisdictional issues remain regarding:

(a) The seaward limits of the OCS?

The seaward limits of the OCS are presumptively coterminous with the seaward limit prescribed by the Continental Shelf Convention. These limits are presently being debated in the preparatory conferences to the forthcoming Law of the Sea Conference. From the viewpoint of marine transportation, maritime safety, pollution abatement and recreational use, the geographic seaward limit of the OCS is of little direct impact.

(b) The seaward limits of state jurisdiction?

The seaward limits in the Gulf of Mexico of the submerged lands of the states of Florida and Texas, by virtue of the 1960 Supreme Court decisions, are set at up to three marine leagues (within historic boundaries) from the base line. This is then the shoreward limit of the OCS in these two coastal areas. Under the Submerged Lands Act, the United States retained in this area all its navigational servitude, and rights in, and powers of regulation for the purposes of navigation. However, the authority which the Corps of Engineers and the Coast Guard exercise with regard to protection of navigation (such as permits for obstructions and navigational lighting requirements) derive from statutes applicable on the one hand to the navigable waters of the United States—which includes the territorial sea—and on the other hand from the OCSLA. Literally none of these statutes have application in the band between the territorial sea and the inward boundary of the OCS. Because of this the authority of the appropriate agencies to act within the six mile band is ambiguous. In our view legislation is desirable to eliminate this ambiguous situation with respect to Federal authority since the personal jurisdiction which the United States may exert over its nationals in these areas is not adequate to deal with navigational and other safety problems.

G. JURISDICTIONAL ISSUES

2. *"Provide a summary of pending proposals for offshore terminals, supertanker facilities, offshore nuclear facilities, and other development projects which in whole or in part would be located in the OCS. What, if any, Federal permits and/or licenses are required under present law for these projects? Is additional Federal legislation dealing specifically with proposals of this nature required or desirable?"*

In our view the establishment of offshore terminals, supertanker facilities, offshore nuclear facilities and other developmental projects beyond territorial waters are not subject to the provisions of the OCSLA—with the possible exception of terminals and facilities providing service for petroleum and gas extracted on the OCS. Control of offshore terminals, etc., is not within the purview of the Continental Shelf Convention. There do not appear to be any direct Federal or State statutes which can reach such activities beyond the territorial sea at the present time. The general principle of extra-territorial jurisdiction over United States nationals is inadequate in the absence of further legislation. Moreover, in the view of the United States, international law does not prohibit the nationals of one country from establishing structures unrelated to continenal shelf resources on the continental shelves of other countries. There is little customary international law on this topic inasmuch as the previous state of technology was primitive enough to preclude such erections in the high seas. The Netherlands and the United Kingdom have dealt with so-called pirate radio stations located on structures beyond the territorial sea (on abandoned WWII flak towers) by unilateral action. At least one scientific research platform has been erected by one nation on the continental shelf of another nation without obtaining permission on the basis that the activity was not subject to the Continental Shelf Convention.

The Territorial Sea and Contiguous Zone Convention permits a coastal state to take action in the contiguous zone to prevent infringements in the territory and territorial sea of its customs, fiscal, sanitary and immigration regulations. Thus there is an internationally sanctioned authority to deal with these structures for these purposes as far from shore as twelve miles. However, while this distance may seem great today, it is quite conceivable that terminals and other facilities may be located at a further distance from shore. Additional Federal legislation will be necessary in order to exercise effective jurisdiction over offshore terminals, supertanker facilities, offshore nuclear facilities and other similar projects. Particular attention should be paid to the necessity of considering all of the other uses of the same area in order to minimize conflicts.

We feel that the proper basis for the exercise of jurisdiction over such offshore structures is through the link with the shore. That would be done by conditioning the licensing or connecting of the structure (pipeline, cable, roadway, or whatever other link may be used) with the territory on the United States upon compliance with appropriate control measures including those relating to domestic or foreign vessels servicing them. We view the use of a geographic jurisdictional device—particularly one which would purport to regulate such structures beyond twelve miles from shore—as a very poor method and one which could have adverse repercussions with regard to Law of the Sea issues. We would also favor the use of the personal jurisdiction device as a complementary basis.

Because the OCSLA and the Continental Shelf Convention are so closely interrelated, we consider it to be extremely unwise to attempt to construe the OCSLA as giving jurisdiction over these offshore terminals because this could stimulate either extensive jurisdictional claims by other nations or an expanded interpretation of coastal state rights under the Continental Shelf Convention.

The Coast Guard is participating with other Federal agencies in the CEQ Supertanker Study. The study will investigate the probable environmental effects of utilizing very large tank vessels (in excess of 100,000 DWT) to import oil to the United States. The study will consider the use of offshore terminals and other facilities to accommodate these large vessels and is expected to be completed by late 1972. The Coast Guard is aware of other studies and proposals concerning this subject and reviews them to satisfy NEPA environmental impact statement requirements or offers comments within the purview of our statutory authority.

The following Federal permits and/or licenses are required under present law:

(*a*) Corps of Engineers permit for construction of OCSLA structures on the OCS (33 USC 403, 43 USC 1333(f)).

(*b*) Coast Guard authorization for the operation of required lights and fog signals on structures on the OCS erected for the purpose of exploring, developing, removing, or transporting resources from the OCS (54 USC 1333(e), 33 CFR 67).

(*c*) Coast Guard authorization for any discretionary aids to navigation to be established in connection with an offshore project subject to the jurisdiction of the United States. (14 USC 83, 33 CFR 66)

3. What formal or informal procedures are used by the Federal agencies to ascertain and consider the interests and views of individual coastal states regarding Federal leasing and management decisions for OCS lands?

In view of the fact that we are not thoroughly familiar with the detailed procedures related to the above question, we have elected not to answer this question.

4. "What should the role of State government be with respect to Federal decision making concerning:

(c) Environmental regulations on OCS lands bordering the States' jurisdiction?"

As a general proposition the Coast Guard feels that any major human activity should be subject to but a single set of rules. In the field of maritime commerce, for example, we believe that the subjection of such commerce in different areas to different sets of laws tends to impede and reduce efficiency. Thus we believe that differing State environmental protection statutes are deleterious and that the proper solution is a uniform national approach. We have made this point in the reports prepared by this agency as required under Sections 11p4 and 12g of the FWPCA. We feel no differently concerning the regulation of the petroleum and gas extraction industry, particularly with reference to the environmental protection regulations. It does appear illogical to have one regime of environmental protection applicable within the territorial sea to offshore structures and a different regime applicable beyond the territorial sea. Section 11 of the FWPCA applies to offshore structures within the territorial sea and provides for Federal environmental regulations by EPA. It does not in and of itself preclude State regulation. Section 11 provides a liability regime and cost recovery limited to Federal activities for these structures. Any State or local action taken with regard to similar activities would be subject to the liability regime of state law. Moving seaward but a few miles to the OCS, the structures there are regulated, from an environmental protection standpoint, by a different Federal agency, and there is no Federal statutory liability regime for governmental removal activities. If the adjacent State happened to have a regime for pollution liability applicable to structures before the enactment of the OCSLA, that law would of course remain applicable by reason of the assimilative provision of the OCSLA. However, any State law subsequent to August 7th, 1953, would not be assimilated by reason of the language of the OCSLA.

From the foregoing precis it is obvious that there is a very confused legal situation pertaining offshore in matters such as environmental protection in which there is no uniformity of Federal law. This makes it difficult to assess what the role of the adjacent State should be. Several States have recently enacted far reaching environmental protection laws which might have application to OCSLA structures on the Outer Continental Shelf if the assimilative provisions of the OCSLA were amended to include current State law. However, this would not avoid the situation of adjacent States having differing regimes. In this connection it should be observed that the extensions of the State boundaries onto the OCS have never been accomplished and thus it is difficult to determine with regard to a structure located near the area where the boundary could conceivably run, which state's laws are applicable by assimilation.

We feel that Federal and State law should, insofar as possible, be identical in order to assure uniformity of treatment of a problem that does not change because of political boundaries.

5. Are there high priority research or administrative programs related to OCS administration that remain unfunded, underfunded, or short of personnel?

Coast Guard emphasis on OCS craft inspection and surveillance which has followed increased awareness of environmental hazards has necessitated diversion of resources from other priorities. Although partially met through the budgetary process, increased personnel and resources for inspection of rigs, transportation, equipment, and enforcement of aids to navigation requirements will be required if it is determined that the program should be intensified. Development of a more comprehensive safety program for the OCS would, of course, necessitate additional funding dependent upon the program.

J. Environmental Protection

1. What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development in: (a) Geophysical exploration? (b) Drilling and production? (c) Undersea pipeline construction and operation? (d) Tanker operation? (e) Port and processing facilities? (f) Onshore pipeline construction and operation? To what extent is each of the above a matter of: (a) Chronic waste discharges in water? (b) Episodic (accidental) waste discharges in water? (f) Navigation safety?

Environmental risks related to OCS oil and gas development include a number of areas in which the Coast Guard has considerable interest, expertise, and responsibility. In some cases, the Coast Guard involvement is that of the Federal agency with primary responsibility; in others it is more peripheral and related to long standing statutory responsibility concerning safety of life and property at sea. This involvement includes law enforcement activity combined with recommendation and moral suasion in many areas of safety where Federal regulation does not presently exist.

An effective forum for development of Coast Guard regulations and for exchange of views regarding safety and pollution avoidance has long existed through the mechanism of the National Offshore Operation Industry Advisory Committee to the Marine Safety Council (formerly the Offshore Operations Advisory Council). Typical of the contributions of that Panel is the "Manual of Safe Practices in Offshore Operations" (November 1967), a volume of recommended safe practices. The extensive minutes of the Committee's meetings reflect the broad scope of its concern with safety and environmental consideration.

J–1—"What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development in: (a) Geophysical exploration?"

Geophysical exploration in OCS areas generally entails the environmental risks normally associated with the operation of water craft as well as those associated with the exploration process itself. Although not directly involved with the later, the Coast Guard has been involved through complaints by fishermen over the effects that the explosive charges formerly used quite widely in exploration have on fish. The (United States) vessels themselves are addressed by marine safety regulations with application and scope dependent upon the vessel size, propulsion, and operation. Comprehensive regulations (46 CFR 188 to 198) issued during 1968 address the inspection and certification of oceanographic vessels but apply to very few of the vessels used in oil exploration. Hence, these vessels generally are exempt from comprehensive regulations despite their carriage of considerable quantities of highly flammable compressed gas for exploration usage. Since such cargo constitutes a threat to port safety, the loading is accordingly monitored by Coast Guard personnel.

J–1—"What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development: in (b) Drilling and production?

Responsibility for conservation of resources and avoidance of product loss during drilling and production, some of which is conducted on unmanned platforms, is tasked to the Department of Interior. The Coast Guard has responsibility for all discharge removal as well as for prevention of pollution from the vessels which supply the drill and production rigs. As previously described, extensive surveillance by Coast Guard air and water craft is conducted to locate spills so as to assure prompt remedial action.

Discharge prevention measures include the requirements for markings and devices to avoid vessel/rig collision and for shipping fairways. Considerable effort is expended in assuring that warning devices are operable. The need to assure that the rigs are located so that they do not force the huge vessels now transiting the OCS area to make difficult maneuvers to navigate cannot be overemphasized.

In accordance with the 1958 Convention on the Continental Shelf, Title 33 of the Code of Federal Regulations was amended to provide for the establishment of Safety Zones around offshore structures engaged in resource exploitation. The regulations became effective on 7 January 1972.

J–1—"What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development in: (c) Undersea pipeline construction and operation?"

The transportation and connection of pipeline components is usually via vessels, all of which are subject to some degree of Coast Guard control. The environmental risks associated with laying the pipelines are subject to review by other agencies. However, this review does not consider hazards to life such as the radiation exposure to which the workers are subjected during non-destructive testing of pipeline joints.

The location and protection given to pipelines directly relates to their likelihood of being damaged by storms, by fishing harvest activities, or by the operations of ships. For the most part pipelines are untrenched and accordingly are vulnerable to these hazards. The magnitude of pollution potential is related to the effectiveness of devices installed to isolate pipeline sections in the event of a rupture. Undersea pipelines, even when buried beneath the seabed, may be damaged by vessels, anchors or spuds. Since pipelines are rarely direct obstructions to navigation, regulations do not presently require marking, charting the location, or centralizing location of pipe in areas of the fairways.

Although Coast Guard authority does not speak to the locations of pipelines, our involvement in pollution surveillance and removal, in marine safety and in pollution prevention prompts our concern over less than optimum pipeline location and protection. The needs of the mariner definitely should be considered in approving pipeline location. This would require the location of many pipelines to be marked, particularly where they cross fairways and channels. In addition, these pipelines should be constructed in a manner that makes them more resistant to damage by external hazards.

An interesting development concerns the usage of manned submersible vessels for examination of pipelines, capped wells, and other underwater installations. The Goast Guard is the lead agency in developing safety regulations for these vessels and is also charged with providing them with assistance in times of emergency.

J–1—"What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development in: (d) Tanker operations?"

Any sizeable increase in tank vessel traffic in the areas proximate to our shores would result in increased risk of environmental degradation unless offset by a continued, vigorous marine safety enforcement program, possibly supplemented by additional authority to control marine traffic.

Short distance transport from the OCS site to the mainland using tank vessels rather than pipeline would presumably, for economic reasons, utilize barges or self propelled vessels smaller than those used to import oil from overseas. Potential oil discharges from such operations would result from factors such as tank cleaning or ballasting, structural failure, bilge pumping, equipment failure, tank overfill, and collisions or groundings.

Presently tolerated tank cleaning and ballasting techniques conducted outside the line of demarcation set by the present international convention, including the "load on top" procedure, result in sizeable polluting discharges which are at least somewhat distributed throughout the oceans. Greatly increased tanker traffic in our coastal waters could not include utilization of these procedures without a corresponding increase in environmental damage. Tank cleaning and ballasting in some degree would still be necessary but would have to be adapted to meet our already stated goal of "complete elimination of intentional oil discharge into the ocean." Fortunately, considerable work already has been done in this area under the auspices of the Intergovernmental Maritime Consultative Organization (IMCO). IMCO member's efforts include the initiation of special studies to develop practical international standards to be incorporated in a 1973 IMCO Marine Pollution Convention. The United States has taken the lead in conducting two of these studies germane to the problems of tank cleaning and ballasting—"segregated ballast tankers" and "dual purpose collapsible tanks." The first study has been completed by a joint effort of the Coast Guard, the Maritime Administration, and the American Institute of Merchant Shipping. This study will allow assessment of the cost effectiveness of tanker designs incorporating various degrees of segregated ballast in mitigating pollution from intentional and accidental causes.

The second study area is being performed by the Massachusetts Institute of Technology, under a Coast Guard contract. It seeks to determine the feasibility of various configurations of flexible membranes in controlling pollution. Study in this area of pollution avoidance is promising but still in the early exploratory stage.

It is premature to speculate concerning the optimum design of tank vessels to be used in OCS oil transport. However, it seems desirable to have some form of clean ballast system in order to avoid dealing with the alternative of providing for the disposal of dirty ballast without environmental damage.

Through regulations published pursuant to the Tanker Act and other statutes, the Coast Guard exercises comprehensive control over the structural adequacy, manning and operation of U.S. tank ships and tank barges. Periodic inspection of hull and equipment, investigation of casualties, a personnel licensing and certification program, and remedial procedures to remove the documents of individuals found guilty of misconduct, negligence, or incompetence in performing their duties combine to provide an effective *marine safety* oriented program. Needed authority specifically addressing pollution prevention was delegated to the Coast Guard pursuant to the Water Quality Improvement Act of 1970 which amended the FWPCA. Comprehensive regulations based on this Act were published as a Notice of Proposed Rule Making on 24 December 1971, and considered at a Public Hearing held on 14 February 1972. These regulations address tank cleaning and ballasting; bilges, leaks and fueling spills; vessel casualties; and oil transfer operations. They supplement those already being enforced and address all of the several potential sources of oil pollution mentioned above except that of collision or groundings.

Avoidance of collisions or groundings is partially addressed by existing licensing qualifications as well as by requirements for vessel structural adequacy and the comprehensive aids to navigation system which the Coast Guard has established to assist the mariner.

Utilization of relatively small vessels to transport oil from OCS sources would reduce the number of supertankers arriving from overseas and could minimize the consequences of any single water transport caused pollution incident. Greatly increased vessel traffic, particularly of large difficult-to-maneuver vessels such as supertankers, would raise collision probability on the OCS unless preventive traffic control measures were instigated.

Such traffic control measures on the OCS might well be similar to those contained in the Coast Guard's proposed "Ports and Waterways Safety Act." Just as some ports may require a complex system of traffic lanes, check points, communication networks, surveillance devices, and central control stations while others may require a comparatively simple traffic separation system coupled with effective communications or no system at all, so too would be the case with OCS marine traffic concentration points. In a related development, the establishment of shipping fairways has been an important step in promoting navigational safety in the vicinity of oil and gas operation in the Gulf of Mexico. It may well be that traffic separation schemes similar to those adopted by member nations of IMCO, and which are already being operated under Coast Guard supervision in the approaches to certain U.S. ports, also will provide a partial answer. The need for a proper mix of these several approaches to assuring navigational safety requires the participation of the Coast Guard in planning for any future large scale OCS oil development.

As indicated previously, the Coast Guard regulates tank vessels of U.S. registry. However, if vessels under foreign registry engage in the transport of oil from OCS sites, the question then arises as to the control that can be exercised over these vessels. OCS sites covered by the OCSLA are currently deemed points within the United States for the purpose of the coastwise trading laws (Treas Decis 54281). Under this interpretation vessels engaged in the transportation of oil or passengers between the sites and the coast of the U.S. are required to be documented by the U.S., a procedure which contributes to effective control of their operations. This leaves open only the regulation of foreign vessels which might transport oil to or from foreign ports. In regulating the operation of OCSLA structures, the United States could require that foreign vessels touching at such sites agree to meet United States standards and requirements. It would appear that these principles would also obtain in the case of structures on the OCS which might be licensed under future legislation based on further developments in international law.

J-1—"What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development in: (e) Port and processing facilities?"

Loss of product in shoreside transfer terminals has occurred despite the previously described regulations controlling vessel construction and operations, and despite other Coast Guard enforced regulations in Title 33 of the Code of Federal Regulations which address shoreside terminal transfer. Under the relatively recent authority of the FWPCA amendments of 1970, the Coast Guard has published proposed regulations and has held a public hearing on February 14, 1972. These proposed regulations cover a host of equippage, communications, spill avoidance and recovery devices, and terminal operations which should significantly reduce the likelihood of product loss at marine transfer terminals.

After consideration of the public comments received, the Coast Guard will publish final regulations in the near future.

2. "Summarize experience with environmental effects of offshore oil and gas operations in: (a) Gulf Coast; (b) California; (c) Cook Inlet; (d) Overseas.

In 1969, the Coast Guard developed the Pollution Incident Reporting System (PIRS) in an effort to collect information and assess the effect of oil discharges in the marine environment. At present only the data for oil discharges occurring in 1970 are available. The data for 1971 is presently being compiled and will be available in July 1972.

The 1970 data indicates that there were approximately 1,766 discharges in the Gulf of Mexico totaling 4.8 million gallons. Of these 1,766, two discharges accounted for 3.5 million gallons.

In California, there were 471 discharges of 212,744 gallons. The majority of these discharges were associated with ships and onshore facilities.

Alaska had 43 spills of 97,428 gallons in 1970, but only seven totaling 214 gallons were related to an offshore facility.

The figures above are from all sources. Offshore facilities accounted for 882 discharges totaling 3.9 million gallons, most of which occurred in the Gulf of Mexico.

Incidents which involve offshore structures under Federal jurisdiction and which meet the definition of a "reportable marine casualty" are investigated by the Coast Guard to determine the cause for use in the prevention of future casualties. Casualties to artificial islands or fixed structures must be reported to the Coast Guard under any one of the following conditions:

1. If hit by a vessel and damage to property is in excess of $1,500;
2. If the damage to an artificial island or fixed structure is in excess of $25,000;
3. If materiel damage affects the usefulness of lifesaving or firefighting equipment;
4. If there is loss of life; or
5. If there is injury causing incapacitation in excess of 72 hours, that arises out of being connected with the use of or employment of emergency equipment as described in Subchapter N (33 CFR 140–46).

Mobile rigs have been considered fixed structures when working and fixed to the sea bottom. When underway they have been considered vessels which must report casualties in accordance with the rules and regulations covering vessels (46 CFR 136).

The table below indicates casualties to fixed and mobile drilling rigs reported during fiscal years 1966 through 1971 The dollar damage figures are for the most part estimates or approximations. These figures come solely from the vessel casualties and do not reflect mishaps, injuries or deaths that may have resulted when there was no vessel or rig damage (e.g., persons falling or knocked overboard, crushed or maimed by drilling equipment, etc.).

	Waters				
	Gulf	Atlantic	Pacific	Foregin	Totals
Mishaps	274	54	22	13	363
Dollar damage	49,541,000	2,481,000	495,000	331,000	52,848,000

These reports indicate that there were 71 deaths and 82 injuries associated with the above casualties.

3. What in summary, are: (a) Treaty; (b) Federal statutory; (c) Regulatory and lease—contract provisions governing liability of OCS lessees for damages and cleanup costs arising from oil and gas operations conducted pursuant to OCS leases?

(*a*) There are no treaties specifically governing damages and "cleanup" arising from oil and gas exploration/exploitation on the high seas. However with regard to such activities on the continental shelf, the coastal state having jurisdiction under the Continental Shelf Convention clearly has the right to apply domestic legislation including that dealing with pollution damage and "cleanup". The 1954 Oil Pollution Convention and the prospective triad of oil pollution conventions (the 1969 Brussels Civil Liability and Intervention and the 1971 Oil Pollution Fund Convention) apply only to vessels.

(*b*) The FWPCA as amended, by its definition of what are offshore structures, excludes from the operation of the Act any of the structures located beyond the territorial sea.

(c) We understand that the Department of Interior has established pollution liability provisions by regulation. We have some reservation about the effectiveness of this means.

We discuss the possible application of State law to the resource development structures on the OCS in the response to G. 4.

4. "What follow-up action was taken by Interior, the Environmental Protection Agency, the Coast Guard and other Federal agencies after each OCS mishap and what interagency agreements and plans related to coordinated Federal handling of any future OCS mishaps, have been made as a result of these experiences?"

The memorandum of understanding between the Department of Interior and Transportation concerning respective responsibilities under the National Oil and Hazardous Substances Pollution Contingency Plan delineates the areas of responsibility for the Geological Survey and the Coast Guard for oil discharges originating from operations conducted under the OCSLA (enclosure 3).

Follow-up action after an oil discharge is based on the National Contingency Plan and the regional contingency plan for the area in which the discharge took place.

Enclosure 6 is a "Review of the Santa Barbara Channel Oil Pollution Incident," a research report conducted by the Pacific Northwest Laboratories Division of Battelle Memorial Institute for the Departments of Interior and Transportation.

Coast Guard responsibility regarding OCS mishaps includes investigation when the mishap constitutes a "reportable marine casualty" described in the answer to question J–2. These investigations are conducted to determine the cause of the casualty so that this knowledge can be used to avert future casualties.

Several types of investigations of marine casualties are conducted by the Coast Guard under the authority of 46 U.S.C. 239. Major casualties are investigated by a Marine Board of Investigation, usually comprised of three or more senior officers experienced in the field of merchant marine safety; less serious casualties may be investigated by only one officer. If the casualty is significant, a formal hearing may be held; less significant casualties are investigated informally. A narrative report is required in all cases involving death.

Casualties to fixed platforms constructed pursuant to the OCSLA are investigated in a similar manner. Difficulty is sometimes encountered in conducting the investigation since the basic authority is derived from 43 U.S.C. 1333(e). This law, unlike 46 U.S.C. 239, does not include the power of subpoena and the Coast Guard is therefore unable to compel testimony.

A number of severe casualties have been the subject of a marine board of investigation, a procedure requiring a formal "action" by the Commandant of the Coast Guard and by the National Transportation Safety Board. Many of these Marine Boards have resulted in recommendations for new authority, or a change of emphasis or other remedial action on the part of the Coast Guard, the Department of Interior, other Federal agencies or by the National Offshore Operations Advisory Panel, an industry advisory group to the Coast Guard's Marine Safety Council.

Several descriptive Marine Boards are attached to illustrate the extent of Coast Guard's involvement in casualties related to this industry's activities (enclosure 7), including:

1. Marine Board of Investigation; capsizing, SEDCO No. 8 Rig 22, Avondale, Louisiana, 10 August 1956, with loss of life;
2. Marine Board of Investigation; Drilling Barge Mr. K, capsizing of 17 April 1957, in the Gulf of Mexico, with loss of life;
3. Marine Board of Investigation; explosion and fire on board Offshore Platform South Timbalier Block 134–D1, Gulf of Mexico, 26 July 1959, with loss of life;
4. Marine Board of Investigation; Continental Oil Rig 43–A; explosion and fire with no loss of life, Gulf of Mexico, 24 October 1967;
5. Marine Board of Investigation; Drilling Rig Dixilyn 8, Julie Ann capsizing and sinking in Gulf of Mexico, 13 March 1958; and
6. Marine Board of Investigation; Explosion and fire on the Chambers and Kennedy Offshore Platform, Block 189–L and fire on M/V Carryback in Gulf of Mexico, 28 May 1970.

5. "What quantitative information is available about the total costs of past mishaps on the OCS, including oil and gas lost, private and government cleanup costs, loss of fish and wildlife, damage to tourism, reduced property values, and administrative costs?"

Information concern dollar damages of OCS mishaps which were reported to the Coast Guard is included in the answer to question J–2.

6. *"What contingency plans and cooperative arrangements have been effected by industry regarding accidents in offshore oil and gas operations? How would these affected response time, total cost, and environmental impact? Are further measures desirable or required?"*

The National Oil and Hazardous Substances Pollution Contingency Plan is the basic guide for coordinated efforts in cleaning up oil spills. In addition, each of the standard Presidential regions has a regional contingency plan. The National Contingency Plan and regional plans for the Fourth and Sixth Coastal Regions are available if desired by the Committee.

The past year has brought forth a manifest increase in the Coast Guard's ability to respond effectively to pollution incidents. Whenever oil is discharged on the navigable waters of the United States, or adjoining shorelines, the President is authorized to remove or to arrange for the removal of this oil unless it is determined that the removal will be performed properly by the polluter. The FWPCA also authorizes such action in the "contiguous zone established or to be established by the United States." While, as noted elsewhere, the need for executive or legislative action to clearly enunciate a contiguous zone for purposes of the FWPCA is under study as it might affect the imposition of fines and penalties and effecting recovery of removal costs, the Coast Guard plans to take removal action in the contiguous zone at any time that circumstances warrant. The Coast Guard, under the provisions of the National Contingency Plan, provides an on-scene coordinator to coordinate the government's response in the event that pollutants such as oil or hazardous substances are discharged in or threaten waters of the coastal area.

Under existing law, the Coast Guard is the Federal agency to be notified when there has been an oil discharge into the navigable waters of the United States, adjoining shorelines and waters of the contiguous zone. To facilitate this requirement, the Coast Guard recently inaugurated a National Response Center in Washington which receives discharge reports and provides assistance to on-scene coordinators by providing technical advice and information to clean up discharges. In addition, a strike force has been set up which is capable of responding anywhere in the United States when a major discharge occurs. This force is composed of personnel specially trained and equipped for immediate reaction including determination of source, removal operations, and coordination of disparate forces, both organized and volunteer. In order to respond rapidly and effectively in areas where local equipment and resources are not available, the Coast Guard has stockpiled off-the-shelf equipment in selected areas of the nation. Also, equipment such as booms, barriers, and chemicals to reduce the spread of pollutants have been distributed to a number of ports around the nation.

A significant advance in combating certain particular types of oil pollution incidents will be the Air-Deliverable Anti-Pollution System (ADAPTS) which is designed to be dropped by parachute at the scene of a stricken tanker or other vessel and used to offload and temporarily store oil and other potential pollutants before they are discharged into the water. This system consists of high-capacity pumps, transfer hoses, rubberized nylon storage bags, and other related equipment, all packaged for on-site delivery by Coast Guard aircraft. Testing of a prototype of this system has been completed, and the results appear promising. Procurement has been initiated and the system should be operational by mid-1973.

In addition to ADAPTS, other efforts are being undertaken to develop a means of preventing the spread of oil discharged into our waters. Containing discharged oil is a necessary first step in removing it, and in limiting the area polluted. Up to the present time there has been no effective means of preventing the spread of oil discharged on open-water areas. However, a prototype open-water oil slick containment boom recently has been developed and tested that has significantly improved capability for withstanding the forces of the open sea. This barrier can be packaged compactly for ship and air delivery. If the results of the tests are successful, we plan to locate these new oil slick containment booms at major port areas in the near future. So far the results of tests performed on this system are encouraging.

During the coming year, the Coast Guard will also be working on the development of improved recovery devices for discharged oil. Several concepts are being evaluated, including, but not limited to weirs, rotating discs, vortex devices and the use of hydrophobic-oleophilic materials which preferentially pick up oil. In addition to these developmental efforts commercially available equipment for deployment at various Coast Guard units nationwide is being evaluated. Procurement of this equipment is planned in the near future and will provide a removal capability for minor and medium oil discharges.

7. "*What additional geological, biological, engineering or other information is necessary with regard to improving the environmental safety aspects of offshore oil and gas operations? Is there research that ought to be completed before any further offshore leasing? Are there special instances or areas in which leasing should be postponed pending completion of further studies? What time effort and costs would be involved in this research?*"

The Coast Guard has significantly increased its level of surveillance and its ability to detect pollutants in the water. Major research and development efforts to further improve future detection capability have been undertaken. In the past year, the number of offshore air patrols were increased in the areas of highest discharge potential. This expands the likelihood of detecting violators which in turn serves to deter potential violations. Development of an improved airborne, all weather sensor to detect, identify and measure the thickness of various types of oil and to map the extent of oil discharges was initiated in 1971. Field tests and evaluation of a prototype system will be conducted in 1972. In addition to developing a positive method of identifying discharges, it is hoped that this system will be reliable enough to facilitate collection of evidence suitable for the enforcement process.

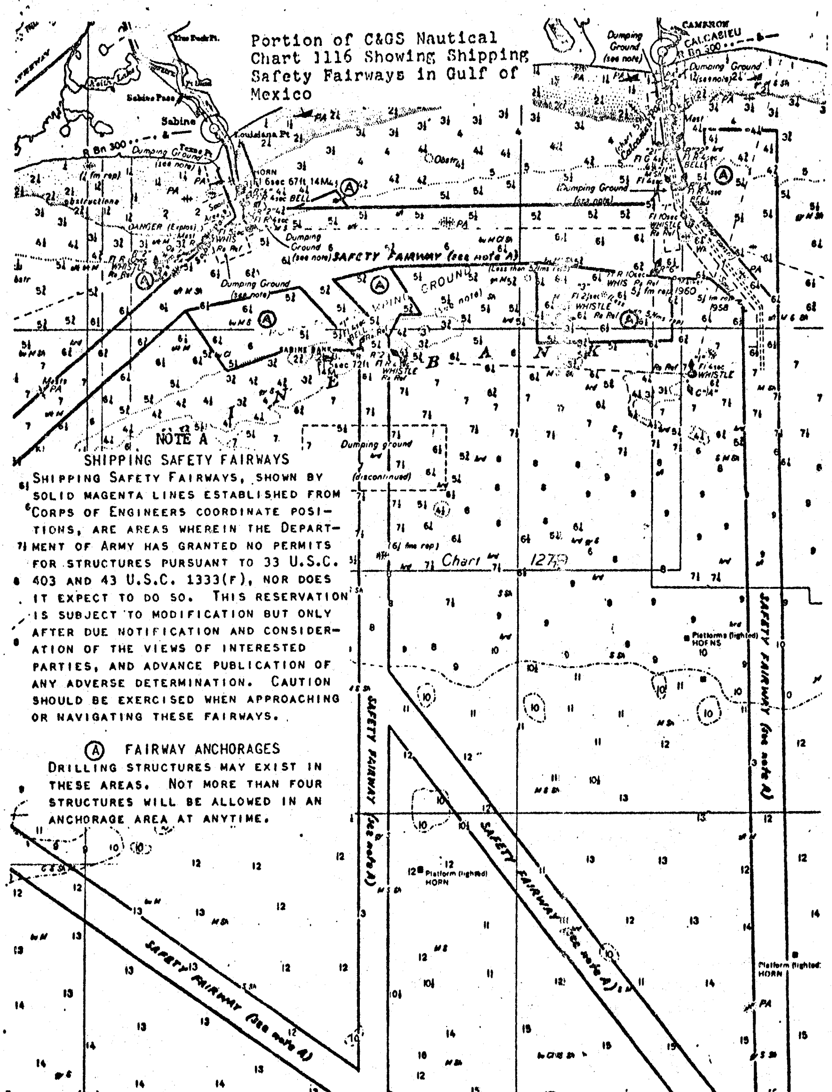
The Coast Guard is presently developing a system to measure the state of the coastal waters in terms of their physics, chemistry, and dynamics. Once an initial baseline is established, further monitoring of these waters gives an indication of the degree to which the environmental quality is being degraded or enhanced. During the coming year the Coast Guard's ongoing research program into the origin, identification and magnitude of oily residue in the marine environment will be expanded both geographically and in technical scope. Improved detection and measurement procedures for marine oil pollution studies are being developed. Baselines and trend indications will be established shortly for major oil ports, their related coastal confluence areas, key beach areas, and important high sea traffic lanes. Special attention will be paid to ascertining the effect of prevailing winds and currents on fluctuations in the oily residue load existing in beaches and harbors. Similar attention will be given to determining the rate at which these oily wastes degrade and disappear from the marine enivronment. Assessment of offshore oil pollution is already being accomplished by towing nets for floating tar balls from Coast Guard operated ocean station vessels, while a prototype "oil-on-the-beach" study is nearing completion near Miami, Florida.

These on-going research programs do not of themselves appear to us to be a basis to delay completion of further offshore leasing.

8. "*What is the state of scientific knowledge on the effect of oil spills on fish and wildlife and the marine environment? What is the level of Federal funding for research and development in this area? Are there research opportunities which are not being pursued for lack of funding?*"

The high costs associated with the monitoring of natural systems have seriously restricted the knowledge avaliable relative to the effect of toxicity of oil spills on fish and wildlife in the marine environment. The necessity for detailed and proper sampling procedures in a sound scientific program together with the time consuming procedures necessary to acquire an analysis that is statistically valid combine to contribute to the costliness of the studies.

In fiscal 1972, the Coast Guard is spending approximately $75,000 on efforts allied with the biological effects of oil discharges. These monies must compete with other high priority ongoing programs within the limited R&D monies available to the Coast Guard. To the best of our knowledge there are no scientific rapid response teams available to study the effects of a spill within a few hours after its occurrence. It is during this initial time period that the bulk of the biological and physical damage is believed to occur. The establishment of such a standby scientific response capability is a research opportunity which cannot be pursued without funding. The Coast Guard hopes to be able to field a response team using FY 1973 funds by September 1972. In the absence of staffing resources for a strong biological emphasis, we will concentrate our studies in the areas of the mechanics of the spill itself.


Portion of C&GS Nautical Chart 1116 Showing Shipping Safety Fairways in Gulf of Mexico
Sabine Pass
Sabine
Louisiana Pt
Texas Pt
CAMERON
CALCASIEU
Dumping Ground (see note)
SAFETY FAIRWAY (see note A)
SABINE BANK
Chart 1279
NOTE A
SHIPPING SAFETY FAIRWAYS
SHIPPING SAFETY FAIRWAYS, SHOWN BY SOLID MAGENTA LINES ESTABLISHED FROM CORPS OF ENGINEERS COORDINATE POSITIONS, ARE AREAS WHEREIN THE DEPARTMENT OF ARMY HAS GRANTED NO PERMITS FOR STRUCTURES PURSUANT TO 33 U.S.C. 403 AND 43 U.S.C. 1333(F), NOR DOES IT EXPECT TO DO SO. THIS RESERVATION IS SUBJECT TO MODIFICATION BUT ONLY AFTER DUE NOTIFICATION AND CONSIDERATION OF THE VIEWS OF INTERESTED PARTIES, AND ADVANCE PUBLICATION OF ANY ADVERSE DETERMINATION. CAUTION SHOULD BE EXERCISED WHEN APPROACHING OR NAVIGATING THESE FAIRWAYS.
(A) FAIRWAY ANCHORAGES
DRILLING STRUCTURES MAY EXIST IN THESE AREAS. NOT MORE THAN FOUR STRUCTURES WILL BE ALLOWED IN AN ANCHORAGE AREA AT ANYTIME.
Dumping ground (discontinued)
Platform (lighted) HORN
SAFETY FAIRWAY (see note A)

Enclosure (1)

10. *Artificial Islands and Fixed Structures used in conjunction with Resource Exploitation.* Detailed regulations regarding the marking of artificial islands and fixed structures, which are erected on the outer Continental Shelf or in the navigable waters of the United States for the purpose of exploring for, developing, removing, and transporting resources from the seabed and subsoil, are contained in 33 CFR 67. These regulations, in general, apply to offshore oil, gas, and sulphur drilling operations. In most instances islands and structures are erected under the authority of a Bureau of Land Management lease or a Corps of Engineers permit or both. Where such a lease or permit has been issued there is no question that the Coast Guard's authority under the Outer Continental Shelf Lands Act to require marking in accordance with its regulations comes into force. However, even if there is no lease or permit, e.g., where an exploratory operation is being conducted for which a Corps of Engineers permit is pending, the Coast Guard marking requirements apply shoreward of the 200 meter (approximately 100 fathom) depth curve (isobath). All cases involving islands and structures deployed seaward of this depth curve should be forwarded to Commandant (L) for resolution.

11. *Underwater Completions.* District commanders may require that underwater drilling completions and similar submerged structures that pretrude above the sea bottom on the outer Continental Shelf or in the navigable waters of the United States be marked as follows:

(*a*) *Clearance less than 85 feet.* Underwater completions with 85 feet or less of water over them must be suitably marked for protection of navigation. This would normally be done with lateral system buoys.

(*b*) *Clearance between 85 and 200 feet.* Underwater completions which terminate between 85 and 200 feet beneath the surface of the sea must be suitably marked for the protection of property in situations where they present a hazard to fishing nets or other fishing gear. When capped with a suitable bonnet type arrangement they will be considered not to present a hazard to property. Required marking would normally be orange and white special purpose buoys.

(*c*) *Clearance over 200 feet.* No markings will be required for submerged structures having more than 200 feet of water over them.

Memorandum of Understanding Between the Departments of the Interior and Transportation Concerning Respective Responsibilities Under the National Oil and Hazardous Substances Pollution Contingency Plan

In order to assure the most efficient use of resources under the National Oil and Hazardous Substances Pollution Contingency Plan, the Secretaries of the Departments of the Interior and Transportation agree that the following provisions shall be observed by the agencies of the two Departments in the exercise of their authority and the discharge of their responsibilities under the Contingency Plan.

1. The U.S. Geological Survey has the expertise and capability for coordination and direction in respect to measures to abate the source of pollution when the source is an oil, gas, or sulfur well.

2. The U.S. Coast Guard has the expertise and capability for coordination and direction in respect to measures to contain and remove pollutants.

3. With respect to spills originating from operations conducted under the Outer Continental Shelf Lands Act of 1953, the U.S. Coast Guard shall furnish or provide for the On Scene Coordinator (OSC) with authority and responsibilities as provided by the National Contingency Plan subject to the following qualifications:

(*a*) The authorized representative of the U.S. Geological Survey on the scene shall have the exclusive authority with respect to coordination and direction of measures to abate the source of pollution.

(*b*) The authorized representative of the U.S. Geological Survey on the scene shall make the determination, which shall be binding upon the On Scene Coordinator, that pollution control activities within a 500 meter radius of the source of pollution should be suspended to facilitate measures to abate the source of pollution.

(*c*) The authorized representative of the U.S. Geological Survey on the scene shall make the determinations necessary under Section 250.43 of Title 30 of the Code of Federal Regulations, which shall be binding upon the On Scene Coordinator.

(*d*) In regard to those matters arising under Section 1334 et seq. of Title 43 of the U.S. Code and the regulations and Outer Continental Shelf Orders issued thereunder, the On Scene Coordinator shall communicate with the lessee through the authorized representative of the U.S. Geological Survey on scene.

(*e*) The On Scene Coordinator and the authorized representative of the U.S. Geological Survey on scene shall maintain close liaison in all matters.

4. With respect to spills originating from operations conducted under the Submerged Lands Act of 1953 or in internal waters of the United States, the U.S. Geological Survey, upon request of the U.S. Coast Guard, will furnish expertise, guidance, and such other assistance as may be appropriate in respect to measures to abate the source of pollution when the source is an oil, gas, or sulfur well.

5. This memorandum of understanding shall be reviewed annually and shall continue in force until it shall be amended or terminated by mutual agreement.

Done this Sixteenth day of August 1971, at the City of Washington, D.C.

For the Department of the Interior:

WILLIAM T. PECORA,
Under Secretary of Interior.

For the Department of Transportation:

JAMES M. BEGGS,
Under Secretary of Transportation.

INTER-GOVERNMENTAL MARITIME CONSULTATIVE ORGANIZATION,
MARITIME SAFETY COMMITTEE,
February 27, 1967.

SAFETY ASPECTS OF OFFSHORE INSTALLATIONS IN THE GULF OF MEXICO

NOTE BY THE GOVERNMENT OF THE' UNITED STATES

The exploration for and mining of mineral resources, principally petroleum, gas and sulphur, beneath the sea bed has reached its greatest point of development in the bays, sounds and continental shelf off the coasts of Louisiana and Texas in the Gulf of Mexico. Inasmuch as extensive petroleum and gas deposits, particularly in the State of Louisiana lay under swamps and marshlands, the technological advances necessary to explore and exploit these deposits, which entailed the shift from a terrene to a marine type of operation, took place in this region quite early. The richness of these deposits resulted in a proliferation of marine installations and the gradual extension of these operations into deeper and deeper waters followed the discovery of extensive petroleum and gas fields at ever increasing distances from the coast.

As is not uncommon, the technological advances have proceeded at a more rapid rate than that of the abilities of the various cognizant governmental and private agencies to recognize and deal with them. The growth of this specialized industry has been such as to necessitate ad hoc and interim safety measures and these temporary measures have, to some extent, become the permanent provisions.

It is the purpose of this paper to present the extant measures which the United States employs in the area of safety regulation of these offshore installations and to suggest as well lines of thought regarding improvements which our experience has indicated may be necessary.

At the outset, there is a terminology or descriptive phrase problem which is not susceptible of easy solution. The Continental Shelf Convention employs the phrase "installations and other devices for the exploration and exploitation, etc. etc.". This phrase is rather cumbersome. The term "drilling rig" is too restrictive since in truth it refers only to the "hole factory" without connoting the devices subsequently employed in the production stages. The industry itself has not settled on a generic term. The word "template" which has reference to a portion of a fixed structure is commonly used in the industry but it is clearly inappropriate to the floating, submersible, and self-elevating devices. Equally the term "offshore structures" does not really fit the bill since it does not comprehend vessels. "Artificial island" has connotations which can be inappropriate as well. The concept of employing an acronym is appealing, but in the English language at least, varying combinations of appropriately descriptive words seems to be mainly unpronounceable or have little esthetic appeal. It might be that a generic term, or possibly an acroym exists in another language. The use of the Japanese word "tsunami" in lieu of the inaccurate term "tidal wave" comes to mind, with the caveat, however, that "tsunami" in Japanese means tidal wave. For want of a better term the word "platform" will be used in this paper with the understanding that it herein connotes the entire galaxy of devices employed offshore with the exception of the service or logistics vessels.

The field of safety regulation can be conveniently divided into two broad categories: Internal or intrinsic safety measures, and extrinsic or external measures. The latter will be dealt with first.

Extrinsic safety measures are those measures taken to protect marine and aerial traffic from the platforms, and conversely. They are all based upon the concept that if marine and aerial traffic can be appraised of the existence and location of a platform, in sufficient time, the traffic can, by changing course or altitude, avoid collision with the platform.

In the Gulf of Mexico, the first provisions that were taken in this regard have remained essentially unchanged. These provisions consisted of the display of a light and the sounding of a fog horn.

It is generally considered that in daylight with reasonably good visibility, the platform itself provides the best signal indicating its existence. With regard to the smaller platforms, particularly those located remotely from the larger complexes of platforms, and in consideration of the enormous vessels now being built, with their reduced maneuvering capabilities, it may be necessary to consider the use of fluorescent materials on these platforms to increase their conspicuity or visual range. While in the United States these materials are presently being employed in our public system of aids to navigation, we have not yet found the need to prescribe such measures for the platforms.

With regard to night-time and conditions of reduced visability, reliance is placed, of course, on lights and audible signals, and a lesser extent, retro-reflective material. In view of the very large number of platforms involved, over seven thousand, the fact that many are portions of a complex of structures in close physical proximity and their geographic relationship to marine traffic patterns, the United States has established differing signal requirements which depend upon the applicability of these factors.

In general, the platforms have been divided into three categories based upon geographic locations, and termed, quite arbitrarily "A", "B", and "C" class. The class C platform is one located along the coast in less than two fathoms of water and within bays and sounds. Class C platforms display one or more white or red quick flashing lights visible at a distance of at least one nautical mile at least 90 per cent of the nights of the year. Audible signals are required only if the platform is adjacent to a navigation channel or fairway. The Class B platform is one located in a depth of water between two and five fathoms. This platform displays a white light or light visible at a distance of at least three nautical miles. Additionally the platform must sound a fog signal having an audible range, under certain prescribed conditions, of not less than one half of a nautical mile. The class A platform displays a white light or lights visible at a distance of at least five nautical miles, and sounds a fog signal with an audible range under certain prescribed conditions of at least two nautical miles.

Since it is recognized that this general classification into three zones does not necessarily fit all situations, there is provision in our regulations to permit or require, as the case may be, signals of a different class than the geographic conditions alone would dictate. Thus, in the case of a platform located in the class C zone but adjacent to a heavily travelled naviagtion route, the higher requirements of a class B or possibly class A platform would be imposed.

The zone classification concept has been employed in the Gulf of Mexico. On the west coast of the United States no zones have been established as yet and each platform is considered on an individual basis.

The physical dimensions of a platform govern the number and arrangement of the lights with a basic view toward providing the mariner with the unobstructed sight of at least one light, regardless of the angle of approach until he is within fifty feet of the platform. Satellite structures such as pilings or flare templates when located within 100 yards of the platforms needs only be marked with retro-reflective material. The presumption made with regard to these satellite structures is that any mariner having need to proceed that closely to the platform would in all prudence be using a searchlight.

Additionally, where there are large complexes of platforms, in such proximity as to preclude ordinary marine traffic from entering the complex, perimeter lighting is allowed. Similarly where one fog signal will provide adequate protection for two or more platforms because of their proximity, that is all that is required.

The characteristic of the lights as quick flashing was an interim measure taken during the infancy of the offshore industry, and the rapidity of proliferation of the structures employing this characteristic precluded the change to another characteristic without the imposition of an economic hardship upon the industry. The International Association of Lighthouse Authorities has recommended a characteristic of a two short one long sequence which is the Morse code letter U. This signifies the mariner that he is "standing into danger." With the wisdom of hindsight, it could be considered that this characteristic should have been established at the outset. However, to change all of the existing lights in the Gulf of Mexico off the coast of the United States would cost well in excess of a million dollars. The rapid conversion of the flashing mechanism from a mechanical time to a solid state electronic device makes the change to a new characteristic even more expensive. The present equipment cost in the United States of one of these solid state flashers is slightly in excess of $300. We are concerned with more than seven thousand platforms, almost half of which are now equipped with the new flashing mechanism.

Thus, to the United States the question of what is the best signal characteristic has a very strong economic overtone, and the matter of funding such a change is quite serious. The same problem, to a lesser extent, of course, presents itself with regard to the changing of the characteristic of the audible signals.

Another factor which has become of increasing magnitude is that of the effect of background lighting upon the conspicuity of a signal light. This problem is not limited to the platforms alone. It exists with regard to our public system of aids to navigation in every harbour. While we do not have the neon sign infilerating our continental shelf as yet, the number of platforms alone in certain areas is such that the distinguishing of a particular light from the other obstruction lights is difficult. Compounding the situation is the number of work lights, gas flares and other miscellaneous light sources which exist in profusion. Again, had we the job to do over again with the benefit of the experience we have gained, consideration would probably have been given to lights of greater conspicuity.

The matter of background noise with regard to the audibility of the fog horns has been given intensive study. The broad conclusion is that large vessels have a low background noise level and that small vessels have a quite high level. But the greater maneuverability of the smaller vessels reduces the critical audibility range. Our casualty experience in the area indicates that the present audibility levels are adequate.

These are the basic extrinsic safety measures that the United States has undertaken directly involving the platforms themselves. As you know, the Continental Shelf Convention has a provision for the establishment of safety zones. The United States has pre-existing enabling legislation for this provision, but we have not established any such zones as yet. From the viewpoint of the collision hazard, the safety zone concept does not seem to add a great deal in our view. If the mariner cannot or does not see the platform itself, it is most unlikely that he would become aware of the safety zone.

Of course it is recognized that the safety zone as a prohibited area into which vessels could not go may be employed to reduce certain other hazards. One that comes to mind is the accidental ignition of explosive fumes surrounding the platform by an intruding vessel in some manner. Our experience to date has been that this is not a problem, and the industry has not pressed the government for the establishment of such zones. The safety zone, to have legal effect must be published and described in our public regulations, and in all probability should be charted as well. Faced with seven or more thousand possible safety zones, and the description, publication and charting problems involved, we prefer alternative solutions if possible.

The lights and fog signals prescribed for the platforms on the continental shelf of the United States have been described. However, there is a difficulty which in our view must be settled at the international level. The difficulty lies with those platforms which are, in truth, vessels. Some of these mobile platforms are ships in every sense of the word, simply having a drilling rig as an added piece of equipment. The display of the lights and sounding of the signals prescribed by the International Rules of the Road with regard to this class of platform may not raise any serious difficulties. But when a huge triangular column stabilized floating platform is considered, the situation becomes somewhat ludicrous. The International Rules of the Road do not, in our view, make provision for the platform which to the passing mariner appears substantially identical to a fixed platform, and yet is in fact, a vessel of sort. The owners of these platforms should not be placed in the unhappy position of having to hazard a guess as to whether to display the obstruction lights of a fixed structure or those of a vessel at anchor or engaged in underwater construction with the distinct possibility that an admiralty court might decide to the contrary. As a general rule, the conspicuity of the lights prescribed for the fixed platforms is greater than those prescribed by the Rules of the Road. The fog signal provisions of the International Rules for large vessels, at anchor, i.e. a bell in the forepart and a gong in the afterpart are particularly inappropriate to a structure that is essentially equilateral.

The Convention on the Continental Shelf is concerned, *inter alia,* with the matter of giving the mariner due notice of the existence and location of the platforms. The United States has, for a number of years, published notices to mariners so doing. In view of the great number of platforms, in the Gulf of Mexico, we have published a special notice. Each structure is identified by name, owner, and location. From a realistic point of view, it is well nigh impossible for the mariner to undertake the plotting of all these platforms upon the charts. Indeed, there are no official charts in existence which show all of the platforms. To be navigationally useful, the charts would have to be on a very large scale and would have to be reprinted at very frequent intervals. With the increasing employment of the mobile platform, drilling locations are occupied by visible structures for a relatively short period of time, and there is a very real problem in keeping up with the changes in location. Attempting to provide up to date information on this subject and making it available to mariners coming from all parts of the world is a staggering problem.

Accordingly, the United States has taken a differing approach to the solution of the notification problem in the Gulf. We have established a system of fairways leading to all of the principal American ports in the Gulf of Mexico. These fairways should not be confused with sealanes, which have been developed for another reason. Briefly, a sealane in terms of recent developments is a one way routing for seagoing vessels. Sealanes thus appear in pairs with an intervening neutral ground. A fairway, as employed ni the Gulf, consists of a lane two miles in width in which the erection of platforms is prohibited. These fairways are published in our Code of Federal Regulations and are being printed on the series of charts covering the Gulf. The first of the series was published a year ago and by the end of this year most, if not all of the issues will have been completed. Thus the mariner need only stay within the fairways to avoid any difficulties with the platforms. Our present problem is simply one of publicity. It will take time to fully apprise the maritime public of the existence and usefulness of these fairways. They impose no legal requirement upon the mariner to follow these fairways—he can go where he wants. But they do provide an assuredly safe means of traversing the continental shelf which is so liberally studded with platforms. We feel that it is the best solution to the problem of notice. We also feel that the earlier that this step is taken in other geographic locations, the fewer conflects will arise.

To extend a fairway through a producing oil field and require as a concomitant thereof the removal of some of the platforms is not only expensive, but is contrary to a number of public and private interests. The right to drill and produce has been purchased at considerable cost, and substantial revenues from the production are gained by the Government. There can be no uncertainty regarding the tenure of a production lease or the right to the continued existence of a production platform without serious and adverse impact, in particular upon future operations. Accordingly, removal of an existing platform is unacceptable. An alternative is to have the fairway dog leg around existing structures. This is unsatisfactory since it complicates unnecessarily the employment of certain aids to navigation, such as radio beacons, where a straight line of approach is preferable. The establishment of fairways before the arrival of the platforms avoids many headaches.

We have observed that the charts published by other nations for the Gulf of Mexico do not present a true picture of the number of platforms on the continental shelf. We strongly recommend that all agencies publishing such charts depict the fairways on them.

The state of the technical art has reached the point where after a well is drilled, it may be "cut off" near the sea bottom or mudline. Whether the well is to be placed in production or held in reserve, the well head is provided with a small structure extending about ten to twenty feet above the sea bottom. The size and height of this structure may vary somewhat and there is no good prediction as to what this submarine platform will be like even a few years hence. There are about a hundred such installations in existence in the Gulf at present. Already radioactive isotopic thermal electric power generating devices are being employed experimentally to provide power to turn valves when signalled from the surface. A grouping of these underwater completions may surround one central collecting platform which extends to the surface being interconnected with pipelines.

Thus a novel problem is presented. While we have heretofore considered the platform itself as providing the best daymark and radar target for aids to navigation purposes, this is not true with the subsurface structure. Compounding the problem is the present vessel construction trend which is moving toward greater and greater drafts. On a shallow continental shelf, the possibility of a subsurface structure constituting a hazard to surface traffic is an increasing one. The obvious method of marking the underwater completion or cutoff is by means of a buoy. The buoy, however, must be an effective signal yet of a practical size compatible with the tender vessels and equipment that the maintainer could reasonably be expected to have for setting and maintaining the aid. Whether or not these subsurface platforms will proliferate to the extent that a distinctive buoy peculiar to this man-made obstruction would be desirable can only be conjectured. Our experience in other areas of the offshore industry would indicate that the growth will probably exceed present predictions.

But again, the employment of the fairways—and these underwater competitions are not permitted in the fairways—should keep the problem within reasonable bounds.

Although the fairways have a legal existence and are marked on the charts, we recognize that ultimately a system of aids to navigation delineating them will have to be given serious consideration. Thus we are faced with the technical difficulties of establishing and maintaining accurately positioned aids to navigation in great depths of water, possibly to depths of one hundred fathoms. Our technical staffs are presently wrestling with these concepts.

As yet, we have had no particular problems involving aircraft and the platforms and have had to take no special measures with regard thereto. The ubiquitous helicopter is the universal means of aerial transportation to and from the platforms, and the large number of civilian aircraft so engaged forms a very useful and much used part of the search and rescue forces deployed to render assistance, not only to persons on the platforms but to the passing parade of marine traffic as well.

In addition to a complex communications network of high frequency radio equipment connecting the platforms with shoreside administrative control stations, a telephone cable system is being installed off the Louisiana coast. Inasmuch as the Gulf of Mexico is one of the regions in the world having the highest electronic noise to signal ratio, this telephone system will improve communications reliability, and as a happy side effect provide for better search and rescue communications capabilities.

The next topic is that of internal or intrinsic safety measures. In the Gulf of Mexico the most serious danger is that of the hurricane and its attendant danger to life and equipment. The major safety measures presently being taken are those of removal of floating equipment and evacuation of personnel. Inasmuch as this is an expensive undertaking, very detailed meteorological studies are maintained employing both governmental and private sources to assure that shutting down and evacuation steps are taken far enough in advance to be effective and yet only when such measures are truly necessary. Insofar as protection of life by these means are concerned, the programme has been quite successful. However the structural design of some of the platforms has been insufficient to meet the severity of the storms actually experienced.

The structural design of the platforms, particularly the fixed platforms, has not been the subject of any governmental regulation. Self regulation by the industry has been satisfactory, and the enormous construction costs of the offshore platforms has in itself been of sufficient inducement to assure as good design practices as could be imposed by a governmental agency. It is one thing to set up a building code in a municipality which code is based, quite literally, on the thousands of years of experience that man has had with such work. But it is quite another thing altogether with regard to the off-shore construction work. The precedents are few and paltry, and many of the forces involved are neither well understood nor reduced to meaningful statistics. For example, solely at the election of the men on board a large column stabilized drilling structure, they chose to ride out a severe hurricane in the Gulf of Mexico a year or so ago. The wave measurements that they took were appreciably greater than those mathematically predicted, which fact has given the industry considerable concern with regard to construction parameters.

The next most serious problem is essentially one of attitude. The off-shore mineral mining industry is one that has been transported from a shoreside operation with as few concessions as possible being made to the essential differences imposed by the maritime location. Once the platform has been erected or floated onto location, and when all goes well, the drilling and production operations are quite similar to those of the shoreside operation. Absent the more vexing logistics problems a marine site entails, the similarities tend to breed a disregard of the hazards of the marine location. However, when casualties occur, the isolation of which the mariner is so well aware, serves to intensify and complicate the problems besetting the land oriented drilling personnel. The first aid resources at hand are, essentially, all that will be available, and there is no place to run to.

At this juncture, a distinction must be made, first of all, between the fixed platforms and the mobile platforms, and with regard to the former category, those that are manned and those that are unmanned. Compounding the situation is the status of internal legislation in the United States. While the external or extrinsic safety measures are all subject to federal control, the internal safety measures are subject in the coastal regions to the individual states while the federal government controls those measures only on the so-called outer continental shelf. The outer continental shelf is that portion of the continental shelf lying beyond territorial waters (except in the cases of Texas and the Gulf Coast of Florida where it is the area beyond three marine leagues from the coast). In practice little difficulty has come about as the result of this split in jurisdiction.

The unmanned fixed platform represents the bulk of the offshore platforms. The federal regulations applicable provide for life preservers and ring buoys when crews are working on these platforms and an escape ladder or stairway. Each company has, of course, company safety measures which their employees who visit the unmanned platforms from time to time must obey. These measures have been quite satisfactory and the need for further governmental control has not been indicated.

With regard to manned fixed platforms additional requirements are imposed. Escape ladders or stairways, illuminated personnel landings, perimeter and stairway railings are prescribed as well as life floats or lifeboats, life preservers, ring buoys, medical first aid kits, Stokes litters and emergency communications equipment. Additionally portable and semi-portable fire extinguishers are specified for various locations on the platform such as sleeping accommodations, storerooms, engine, boiler and motor rooms, communicating corridors and communications centres.

The owner of the platform must designate by title and in order of succession the persons on the platform who shall be the person in charge. The platform must be equipped with a general alarm system and a station bill detailing emergency stations and duties of the personnel are prescribed. Emergency drills are conducted monthly.

An area that still needs work is that involved in the transfer of personnel to and from the platforms. This is usually done by a cargo net type of apparatus hoisted by a crane, or by personnel stepping from the launch to the landing platform with the aid of a manrope. This is a hazardous operation even for the nimble of foot. Industry and the government have been studying this problem for a number of years, but a truly satisfactory solution is still in the offing.

As the offshore industry has been in existence as an appreciable specialised portion of the mineral mining industry for about twenty years, there has been, of course, a considerable wealth of experience gained. But the work offshore is not only arduous, it is isolated, and the personnel turnover is considerable in spite of the financial inducements that are offered. Consequently the greater part of the specialized marine knowledge tends to become concentrated in the higher levels of operaions, and insofar as the personnel on the platform are concerned, the landsman's approach to a marine operation is a problem that will probably be with us for quite some time.

Insofar as the mobile drilling platforms are concerned, the parallel with the conventional type of vessels is apparent, and yet the distinctions wrought by the difference in basic purpose are large and the safety measures which have been accepted in the ordinary maritime fields are not quite appropriate in many instances.

The self-propelled mobile drilling platform is indeed a ship in every sense of the word, and with the exception of the increased high weight due to the derrick, no unusual problems are presented. Our rules and regulations for cargo and miscellaneous vessels set forth in the Code of Federal Regulations can be readily applied.

The non self-propelled mobile drilling platform presents a more difficult situation. The original of this species consisted of a drilling rig mounted on a barge. The variations on this theme have been quite diverse. Three generic variants are commonly recognized. One is the submersible or bottom sitter. This platform is towed to the drilling location and then through the flooding of compartments is lowered to the seabed. In the United States we have treated this type as a fixed structure. The second variant is essentially a sort of barge equipped with a number of movable legs. Through various types of mechanisms the legs are lowered to the seafloor and then the barge body is itself elevated above the surface to clear the waves. This self-elevating or jack-up rig exists in greater numbers than any other type. Again for the purposes of safety regulations, we treat the self elevating platform as a fixed structure.

The third category is the semi-submersible or column stabilized platform. This type operates from a floating position. Greater stability is achieved through partial submergence and sometimes the distinction between a semi-submersible and submersible platform is more a matter of degree inasmuch as some platforms can operate in either mode.

Of the three varieties of mobile platform, the jack-up platform has suffered the most casualties. The bulk of these casualties have occurred while the platform was settling upon or lifting off of a drilling site. The assurance of adequate stability during these operations concern not only the naval architect, but the structural and the civil engineer as well. The failure of the seabottom bearing surface to support one or more legs appears to be a matter of serious concern. To a much lesser extent, structural or jacking mechanism failures have contributed to the number of casualties. Very close attention must be paid to the stability during elevating and lowering procedures, and a high degree of co-ordinating of the operation is essential.

The rules and regulations for cargo and miscellaneous vessel are applied to these floating platforms but with considerable latitude. For example, there are no drydocks large enough to contain these huge column stabilized platforms. The current method of simulating drydocking is to reduce the draft to a minimum during ideal weather conditions and inspect the hull, inside and out to the maximum feasible extent. In certain instances the use of divers is advisable. Equally, it is virtually impossible to obtain a good inclining test. The calculated stability combined with the deadweight survey had proven satisfactory in most cases. Stability information is provided by the owner and is approved by the cognizant government agency. The information is required to be available to the operating personnel on the platform. This includes any information on operating conditions which might hazard the unit. Ballasting instructions are reviewed and approved by the cognizant government agency and recommended ballasting and deballasting schedules are included in the Trim and Stability Booklet.

With regard to both the submersible and the semi-submersible platforms the transitional period, in the case of the former from a positive buoyancy condition to a negative buoyancy condition, and in the case of the latter, from the shallow draft to the deep draft attitude, is a critical time and close attention must be said to the ballasting sequences.

We have no specific subdivision or stability requirements as such for the semi-submersible platform. However, during the review of the arrangements, the location of watertight boundaries and watertight enclosures are examined with the view of minimizing downflooding from the geyser during a possible blowout. Those units with their working platforms near the water's surface are particularly susceptible to this problem. Ballasting and dewatering equipment such as pumps and valves are usually remotely operated, but provision must be made to permit access to this equipment should the control system fail.

A qualified man-in-charge, a properly trained crew, and proper equipment, including a central control station must be provided. A most necessary ancillary is a station bill. The close parallelling of the conventional shipboard organization with its clearly defined duties and lines of responsibility is most important on the floating platform.

In view of the great potential hazard of an explosive gaseous condition, the electrical installation must be designed to permit the complete shut-down from a central location. We require explosion proof equipment within fifty feet of the drilling wellhead. Access or ventilation openings should be remote from the wellhead to preclude direct intake of gas. The structural fire protection requirements of the cargo vessel are applied to the floating platform.

While a fire-fighting water supply is readily available when the main body of the platform remains afloat, this is not so where the working platform may be fifty to eighty feet above the water. Our present requirement is for a water tank at this level with a prescribed minimum supply as well as a reliable replenishing pump.

As in the case of the fixed platforms, the matter of evacuation of personnel from heights upward of fifty feet require descent ladders so located as to afford maximum protection against a possible surface fire in the drilling slot.

We have imposed requirements upon the floating platforms in excess of those imposed on the fixed platforms because of the susceptibility of the former to sink. Thus the design of the helicopter landing platforms is reviewed to ascertain that not only will the largest landing loads be adequately supported, but that the construction and location will be such that a crash landing will least endanger the floating platform or its personnel. Additional fire-fighting protection is prescribed, particularly if helicopter fueling capabilities are incorporated into the design.

The assurance of adequate safety measures, intrinsic and extrinsic, is a matter of great concern to both industry and government. We consider that the closest co-operation in this regard is essential.

In the United States the Coast Guard is the federal agency having primary cognizance over maritime safety matters. The Coast Guard has established a Merchant Marine Council for the purpose of holding public hearings on proposed regulations as well as a forum for the interchange of ideas and information on topics related to various aspects of the marine industry. Advisory panels composed of representatives ofspecialized fields, such as the tanker trade for example, comprise a valuable adjunct to the Council. One of these panels is the Offshore Operations Advisory Panel which is concerned with matters relating to the platforms. Problem areas are discussed and solutions are put forth for consideration. In this manner safety measures are arrived at. In some cases, these are promulgated in the form of federal regulations. In many more cases, they are established by the industry as self regulating provisions.

Illustrative of the function of this organization is one case involving a casualty to a platform. This involved a catamaran type of floating drilling rig which experienced a gas blowout followed by a severe fire and the capsizing and sinking of the platform. The casualty was thoroughly investigated by the Coast Guard and the report thereof was referred to the advisory panel for review as to measures which could be taken to preclude this sort of occurrence. Such matters as the effect of a massive down flooding, the possible change in buoyancy due to the aeration or gasification of the water, and other items brought into focus by this casualty, have been taken under study by the industry representatives. Some recommendations based on this study have already been made and acted upon.

The manning of the platforms, the mobile platforms in particular, has been the topic of considerable study and discussion by this advisory panel. Different crews, with differing technical specialities, may man these platforms at various times. For example, a platform under tow may have a minimal crew comprising personnel tending to the seamanship end of the business, as well as technicians making the platform ready to settle upon the drilling site. Upon arrival at the site, the crew is augmented to engage in the submergence or jacking-up operation. Once established on site, the drilling crew takes over. From the safety viewpoint, each of these groupings of personnel must have the capabilities of dealing with emergency situations. Thus the manning problem is much more complex than that which exists on a conventional vessel. Interim industry wide standards were adopted several years ago, and these standards are presently under revision.

A situation which has been causing us increasing concern is that of dealing with wrecks on the continental shelves. Hurricanes and severe storms take their toll of the platforms and distribute the wreckage over a wide area. The huge mobile platforms present a special problem. A column stabilized semi-submersible may be six hundred feet on a side and if sunk can constitute a menace to navigation in depths approaching the hundred fathom curve. The removal of a wreck of this size constitutes a massive undertaking and in many instances may not be possible. The problem of locating such a wreck presents unique difficulties. We have found that portions of these sunken structures are unstable and may rise near the surface for a period of time and then subside and even repeat this performance. Wire dragging is thus inconclusive. We are exploring sonic detection methods presently. Marking of these obstructions by buoys in deeper water presents technical difficulties. Quite obviously these wrecks present unusual legal problems as well.

This paper is by no means to be considered exhaustive. There are many factors which have been touched on but lightly. The subject is too large to deal with effectively in one paper. Safety matters relating to the vast number of support and auxiliary vessels involved in the offshore operations is a topic by itself. Floating and submerged collection tanks are a new development. Pipelines are increasing in number and length. They carry not only petroleum, water, and sulphur but gas under high pressure as well. The inadvertent dropping of an anchor on a pipeline could rupture the line with serious consequences. Pipeline problems such as this have not been treated by this paper but the omission falls into the same category as that of the logistics vessels in that it deserves separate consideration.

In conclusion, we can only anticipate that the exploration and exploitation of the mineral resources of the continental shelves of the world will proceed at an accelerating rate and that it will take the full and combined efforts of governments and industry to keep up with the safety responsibilities regarding these platforms.

DAILY DISTRIBUTION OF TRAFFIC IN GULF OF MEXICO, PRESENT AND FORECAST [1]

	Tankers over 100 GRT (1969)	Bulk carriers 100 GRT (1969)	Fishing vessels 100 GRT (1969)	Other vessels 100 GRT (1969)	Total synthesized data (1969) [2]	Total 1972 forecast	Total 1980 forecast (includes TAPS)
Straits of Florida	9		3	7	19	27	21
Eastern Gulf of Mexico	12		2	3	17	19	17
Western Gulf of Mexico	5		1	3	9	6	10
Mobile area	15	3	2	42	62	77	73
Entrance to Mississippi River	3		1	14	18	16	19

[1] This table was prepared from information contained in A Study of Maritime Mobile Satellites, Vol. I, "Merchant Vessel Population/Distribution Present and Forecast", Automated Marine International, Newport Beach, Calif.
[2] Includes all vessels over 100 GRT.

Enclosure (5).
(Enclosure 6 and 7 were retained in the Committee files.)

U.S. COAST GUARD,
May 22, 1958.

COMMANDANT'S ACTION ON THE REPORT OF MARINE BOARD OF INVESTIGATION; "DRILLING BARGE MR. K," CAPSIZING OF, 17 APRIL 1957, IN THE GULF OF MEXICO, WITH LOSS OF LIFE

1. Pursuant to the provisions of Title 46 CFR, Part 136, the record of the Marine Board of Investigation convened to investigate subject casualty has been reviewed.

2. Nine lives were lost, three persons injured and substantial property damage occurred when, on the morning of 17 April 1957, while being towed, the DRILLING BARGE MR. K suddenly capsized in the Gulf of Mexico about 1½ mile ExN from the entrance to South Pass at the mouth of the Mississippi River.

3. The *Drilling Barge Mr. K*, Official Number 272256, owned and operated by the Golden Meadow Well Service Company, New Orleans, La., was a manned, uninspected, steel, slotted type mobile platform, the hull 1026 g.t., length 164′, breadth 54′, depth 11′10″. The elevated superstructure included living quarters, machinery spaces, and a helicopter deck and was fitted with a drilling derrick having a height, when raised, of 183′10″ above the keel. The structure had been designed and built in 1956 by the Bethlehem Steel Company, Beaumont, Texas, for oil drilling offshore in depths not exceeding 14 feet. Ballast tanks within the hull of the barge enabled it to be sunk to the bottom within the 14' range and subsequently refloated for shiftiing to other locations.

4. On 15 April this barge had been positioned near the entrance to South Pass in the Gulf of Mexico, resting upon a prepared foundation of shells. On 16 April adverse weather caused damage to the shell bed, necessitating the removal of the barge so that this foundation might be repaired. At 0700 on 17 April refloating was commenced; the ballast tanks were pumped, the spuds holding the barge in position were raised and shortly before 0900, on an even keel with drafts of 8 feet, towing began with the derrick in the raised position. Because drilling had been prematurely discontinued there was on board a large quantity of heavy steel pipe and other supplies considerably in excess of that normally carried when under tow. An undetermined amount of water remained in the ballast tanks. The fresh water tanks were cross connected with sluicing valves open. At 0938, while proceeding at about 3 knots on a SSW course, wind SE to SSE 10 to 15 mph, with SE ground swells estimated at 3 feet, the barge suddenly began listing to port, and within 2 minutes capsized and floated bottom up. Of the 15 men aboard, 5 were reportedly asleep in their quarters when the accident occurred.

5. Although the derrick had been designed for lowering to a horizontal position, it had never been lowered while under tow, on at least four prior shiftings, Operating personnel apparently were unaware of the hazards involved in the ballasting, deballasting and movement of this vessel, particularly with regard to stability. The Board concluded that the instability resulted from the combined effect of the unusual topside weight of pipe and supplies, the raised position of the derrick, and the water in the ballast and fresh water tanks. The Board further concluded that the upsetting force was derived from the effect of the SE ground swells on the beam of the hull and the probable effect of the wind upon the upper portions of the derrick.

6. The Board recommended (a) the all mobile platforms located beyond the headlands but less than three miles offshore be made subject to the regulations promulgated for mobile platforms on the Outer Continental Shelf; (b) that these Regulations be amended to require the approval of plans, stability tests, and inspection during construction; (c) that these platforms while under tow shall have the least possible number of persons aboard, not to exceed two; (d) that the lowering of such derricks be mandatory, and (e) that the submerging, refloating and movement of these platforms, including preparation therefor, be only under the direct supervision of competent personnel having marine engineering experience and a practical knowledge of stability.

REMARKS

7. Although there appears to have been a possibility that certain design features of this equipment may have created conditions contributory to the casualty, the fact that this rig had been moved on at least four previous occasions without accident strongly suggests the probability that the causative error was operational. Plan approval and inspection during construction will not eliminate operational errors stemming from inadequate knowledge of stability. It is recognized that these mobile platforms are unique in many respects; they are not vessels in the usual sense but the forces and moments affecting equilibrium are constantly present. Stability in this particular type of structure becomes critical when buoyancy is dissipated during the submerging operation and, similarly, foundational stability is lost as flotation is resumed.

8. The problems of safety associated with the operation of these off-shore drilling rigs have been under study by the industry, by various governmental agencies and by others. The equipment, of various types and with many different operating systems, must continue to be regarded as experimental to a great extent. The optimum of safety is often thwarted by conditions necessarily present during any experimental stage. It follows logically that any regulations, safety codes or operational guidelines, to be effective, must be based upon a recognition of all the practical factors involved and the peculiarities of each individual rig.

9. With this in mind, and in view of our favorable experience with the encouragement of industry self-regulation whenever it is consistent with the safety objectives being sought, the Panel of Advisors on Offshore Operations to the Commander 8th Coast Guard District was invited to consider and submit recommendations for a comprehensive code of safe operating practices or other effective means which would reduce the probability of similar accidents in the future. In response thereto a special committee representing the industry made a study of the problem and drafted a "Manual of Safe Operating Practices for

Offshore Mobile Drilling Platforms" which was distributed in the industry for additional study and comment. This proposes certain rules, minimum standards and recommended procedures applicable in general to all such platforms but taking into account the special features and characteristics of the individual rigs. It encompasses the determination of stability; the moving, raising, refloating and submerging of the rig; special hurricane procedure, etc., and includes the correlated subjects of manning, personnel qualification, supervision and responsibilities, use of safety equipment, etc.

10. In view of the progress being made toward the development and industry wide acceptance of a program which will satisfy the requirement for safe control over the movement and operation of these rigs, I find no need, at this time, for further action on the recommendations of the Board. Accordingly, subject to the foregoing remarks, the Findings of Fact, the Conclusions, and the Recommendations of this Marine Board of Investigation are APPROVED.

A. C. Richmond,
Vice Admiral, U.S. Coast Guard, Commandant.

Report of Marine Board of Investigation, April 22, 1957

Convened at New Orleans, La., to inquire into the circumstances surrounding the capsizing of mobile drilling rig, *Drilling Barge Mr. K*, in the Gulf of Mexico, near South Pass entrance, on 17 April 1957, with loss of life.

Findings of Fact

1. On or about 0938, 17 April 1957, the mobile platform *Drilling Barge Mr. K* capsized in the Gulf of Mexico in approximate position 28°59.6′ N, 89°07.3′ W, while underway in tow of tugs *Madeline* and *Itco II*, with loss of nine (9) lives and injury to three (3) persons. This position is approximately 1.5 miles distant and 075° true bearing from East Jetty Light, South Pass.

2. Vessels involved:

(*a*) *Drilling Barge Mr. K*, O. N. 272256, an uninspected steel hull mobile platform of 1026 gross tons, 1026 net tons, dimensions 164′x54′x11′10″, home port New Orleans, La., built at Beaumont, Texas, in 1956, owned and operated by Golden Meadow Well Service Company, Carondelet Building, New Orleans, La. The *Drilling Barge Mr. K* is a slotted type drill barge with elevated superstructure. This barge was designed and built by Bethlehem Steel Company, Shipbuilding Division, Beaumont Yard, Beaumont, Texas, for use in water not exceeding 14′ depth. The barge hull was subdivided into four ballast tanks, two fresh water tanks, one fuel tank, on centerline forward of slot, three fresh water tanks in rakes, one fresh water well on centerline just aft of fuel tank, and one drain well, as shown on general arrangement plan, Exhibit 1. There was a pump deck extending full width and length of barge located 8′ above the barge deck. The quarters and engine house were located on next deck up, which was 32′2″ above keel, and on top of the quarters was a helioport at 46′8″ above keel. This barge was fitted with a derrick for drilling, the drilling floor being aft of quarters and engine house and 40′10″ above the keel. The derrick when in the raised position extended 143′ above the drilling floor or 183′10″ above the keel. The slotted end of hull is considered to be the stern.

(*b*) *Itco II*, O. N. 271737, uninspected steel hull twin screw 600 HP Diesel tug, 63′ in length, 72 gross tons, 49 net tons, built at Lockport, Louisiana, in 1956, home port New Orleans, La., owned by Independent Towing Co., Inc., Harvey, La., and chartered by Otto Candies, Inc., Des Allemands, La.

(*c*) *Madeline*, O. N. 271021, uninspected steel hull twin screw 600 HP Diesel tug, 63′ in length, 53 gross tons, 36 net tons, built at Houma, La., in 1956, home port New Orleans, La., owned by Franklin Towing Co., Inc., Des Allemands, La., and chartered by Otto Candies, Inc., Des Allemands, La.

3. Weather conditions—wind SE to SSE, 10–15 mph, visibility good, 3′ ground swells. Small craft warnings hoisted 8:00 AM (CST) 16 April 1957 from Galveston, Texas, to Pensacola, Florida, for Southeasterly winds about 25 mph, except occasionally around 35 mph in thundershowers throughout the night. Small craft warnings were lowered at 8:00 AM (CST) on 17 April 1957.

4. On Monday, 15 April 1957, the *Drilling Barge Mr. K* was moored on location in Gulf of Mexico, near entrance to South Pass. Mississippi River, at lat. 29–00–20.0 N, long. 89–07–42.9 W, by lowering barge so that it sat on a shell

bed that had been built up at this location. The barge was made fast with its spuds in approximately twelve feet of water. Preparations were begun to drill a well at this site for Humble Oil and Refining Company. On the morning of 16 April 1957 preparations for drilling were completed but the weather began making up (note—small craft storm warnings hoisted at 0800 16 April 1957. (Exhibit 32) and operations were stopped. The seas from the Southeast began washing away the shell bed foundation and Humble Oil and Refining Company ordered barge moved in order to rebuild the foundation. At Humble's orders the tugs *Madeline* and *Itco II* were to tow barge to Joseph's Bayou. About 0700 Wednesday 17 April 1957 preparations were begun to float barge by pumping or "jetting out" the four ballast tanks in the hull of the barge. At some time prior to 0900 the barge was afloat and spuds pulled up into hull. About 0900 the tugs *Itco II* and *Madeline*, made up in tandem ahead of barge, began towing. The tow followed a circular course beginning first to the North and swinging wide around to the East and steadied on a course about SSW. After having been steady on this course an estimated fifteen minutes and at a speed of 3 knots, about 0938 the drilling barge began listing to port and continued on over until it was in a capsized position with the bottom of the hull out of the water. The barge capsized without warning in less than two minutes, resulting in loss of nine lives and injury to three persons.

5. *Drilling Barge Mr. K* was an artificial island which included as integral part of itself features which permit it to be moved as an entity from position to position and to be fixed to or submerged onto the seabed.

6. At the time barge got underway, on or about 17 April 1957 at 0900, draft was reported to be 8′ and on an even keel.

7. The derrick was in the raised position at the time of capsizing with traveling block on the deck at the foot of the derrick and no pipe hanging in the derrick.

8. Tanks in barge were fitted with sounding pipes which extended to the pump deck. These sounding pipes were not utilized to determine the condition of the tanks on the morning of the casualty, nor had they ever been used.

9. Plez Ballard, Assistant Drilling Superintendent for Golden Meadow Well Service, was in charge of the drilling barge at the time of capsizing. Mr. Ballard had gone on board the morning of 15 April 1957 and remained on board until casualty occurred. Mr. Ballard had been on this barge on several previous occasions, including times when it had been pumped out and moved to a new location.

70. M. E. Flower, Tool Pusher, was assistant to Plez Ballard at time of casualty and the person normally in charge of all operation on *Drilling Barge Mr. K.* Mr. Flowers had been working on this barge since August 1956 when it was on first location.

11. According to M. E. Flowers, the condition of the tanks in the barge itself were as follows:

Bow rake tank—dry;
Ballast tank, starboard forward—about 1′ water;
Fresh water tank, starboard amidships—about 3′ water;
Fresh water tank, port amidships—about 3′ water;
Ballast tank, starboard aft—about 1′ water;
Ballast tank, port forward—about 1′ water;
Ballast tank, port aft—about 1′ water;
Stern rake tank, starboard—dry;
Stern rake tank, port—dry;
Fuel tank, on centerline—⅔ full.

12. According to Plez Ballard, the condition of the tanks in the barge itself were as follows:

Bow rake tank—dry;
Ballast tank, starboard forward—4″ water;
Fresh water tank, starboard amidships—about 3½′ water;
Fresh water tank, port amidships—about 3½′ water;
Ballast tank, starboard aft—4″ water;
Ballast tank, port forward—4″ water;
Ballast tank, port aft—4″ water;
Stern rake tank, starboard—didn't know;
Stern rake tank, port—didn't know;
Fuel tank, on centerline—about ⅔ full.

13. The sluicing valve between port fresh water tank amidships and centerline drain well was open. The sluicing valve between the starboard fresh water tank amidships and some drain well was open.

14. The condition of the ballast and water tanks as reported by Flowers and Ballard was based only on their knowledge that the pumps lost their prime and pumped no more water. Soundings were not taken although the tanks were fitted with sounding pipes that extended to the pump deck.

15. *The Drilling Barge Mr. K* was actually and continuously occupied by persons living and accommodated thereon. At time of this casualty there were fifteen persons on board, five of whom were reported to be asleep in sleeping quarters provided.

16. According to testimony of M. E. Flowers, the following stores and supplies were known to be on board at time of casualty:

Reserve mud pit, starboard—5′ salt water;
Reserve mud pit, port—4½′ of 11.5 drilling mud (11.5 lb/gal);
Transverse active mud pit—1′ water;
Longitudinal active mud pit—empty;
Fuel oil dry tank—full;
2251 sacks weighing mud @100 lb/sack—dry mud store room;
400 sacks jell mud @100 lb/sack—dry mud store room;
160 sacks clay mud @100 lb/sack—dry mud store room;
10,700 lbs. caustic soda—dry mud store room;
14,900 lbs. kabroko (phonetic)—dry mud store room;
4,500 lbs. CMCA starch mud—dry mud store room;
1,450 lbs. lost circulation material—dry mud store room;
5,500 lbs. fiber seal—dry mud store room;
250 lbs. fiber tex—dry mud store room;
1,800 lbs. graphite;
6,500 ft. 4½″ drill pipe, pipe rack, port (4½″ pipe @16.60 lbs./ft);
8,000 ft. 4″ drill pipe, pipe rack, starboard;
1,000 ft. 20″ casing pipe, pipe rack, port (20″ pipe @94 lbs/ft);

Note: Pipe racks are fitted each side of slotted section 10′ above the pump deck.

17. According to testimony of Plez Ballard, the starboard reserve mud tank contained 3½′ of 11.5 pound per gallon mud and the port reserve mud tank was filled to within 8″ to 10″ of the top with sea water.

18. According to testimony of Plez Ballard, there was no lifesaving equipment on board.

19. According to testimony of the other survivors there was general agreement that the following equipment was on board:

24—adult life preservers;
2—15 person balsa life floats;
4—ring buoys.

20. The 20″ pipe casing and the mud, caustic soda and other material in the dry mud store room were placed on board after the barge was on location in the Gulf of Mexico.

21. At the time of this casualty this was the heaviest load of material and supplies that the barge had had on board when being moved (p. 105, q. 7).

22. This rig was not equipped with a general alarm system.

23. This rig was not provided with a station bill.

24. There is no record of any Coast Guard inspection for compliance with regulations for artificial islands and fixed structures.

25. There is no record or knowlege of any emergency drills being held by personnel on board.

26. Mr. Steele, Naval Architect, and person responsible for design of the *Drilling Barge Mr. K*, testified that this equipment was designed for marginal offshore waters.

27. Mr. Steele testified as to stability characteristics of this barge and according to his calculations even at an eight-foot draft the range of stability was 23°.

28. An inclining experiment was not performed, and the center of gravity was determined by calculation.

29. Mr. Steele testified the scantlings of the hull were in accordance with American Bureau of Shipping Rules for inland waters. However, the barge was not built to or inspected for ABS classification.

30. The 4½″ and 20″ pipe in the pipe racks moved slightly after the barge started to capsize to port.

31. An inspection of the bottom of the hull by the Board of Investigation while vessel was still capsized found the bottom plating to be intact and undamaged.

32. The tow was made up with the tugs in tanden, the tug *Madeline* in lead, and tug *Itco II* astern of *Madeline*. The *Itco II* was made fast to the *Drilling Barge Mr. K* with a 45′ bridle and hawser of about 300′ long.

33. The person in charge of the tug *Madeline* at time of casualty, Horace Badeaux, testified he had six to seven months experience in charge of tugs but this was the first time he had towed a mobile platform in the open waters of the Gulf of Mexico. It was also the first time he had been in the Gulf of Mexico at South Pass where this casualty occurred. He did not hold any license issued by the Coast Guard.

34. The person in charge of the tug *Itco II*, N. J. Naquin, testified he had six years experience on tugs and had handled equipment similar to this drilling barge on inland waters and the *Drilling Barge Mr. K* one time in open waters. He did not hold any license issued by the Coast Guard.

35. A thunderstorm occurred at time of or immediately after the casualty as evidenced by testimony of Greer Ricks (p. 81).

36. Coast Guard aircraft encountered disturbances upon approaching scene of casualty shortly after it occurred.

37. The following Coast Guard aircraft and surface craft rendered assistance by searching area for survivors:

(*a*) Airplane from CG Air Detachment, Biloxi—Airplane No. UF–1G–1271.

(*b*) Helicopters from CG Air Detachment, New Orleans—Helicopter No. HO 3 S 232; Helicopter No. HO 3 S 235.

(*c*) Patrol boats from CG Moorings, Pilottown, La.—Boat No. 40418; Boat No. 40445.

38. The derrick on the rig was designed to be lowered into a horizontal position as shown in Exhibit No. 2. The barge had been moved on at least four previous occasions and each time the derrick was in the raised position. Testimony further brought out that derrick had not been lowered since being raised on first location.

39. The *Drilling Barge Mr. K* has not yet been successfully salvaged. Golden Meadow Well Service Co. advised by letter of July 22, 1957 that the barge had been sold to A. Marx & Sons, New Orleans, La. on July 18, 1957. On September 1, 1957 the hull, with an undetermined part of the superstructure attached, was towed from location to Crescent Towing & Salvage Co. dock, New Orleans, with the barge still in the capsized position. The Recorder was advised verbally by A. Marx & Sons that the helicopter deck, quarters and derrick were not attached to the portion of the rig towed up river.

40. Local Notice to Mariners No. 44, dated April 19, 1957, issued by Commander, Eighth Coast Guard District, gave notice that the *Drilling Barge Mr. K* was a menace to navigation and this notice is still in effect.

41. The following persons were on board the *Drilling Barge Mr. K* at time of casualty:

Fred Elmer Stanford, Pontchatoula, La.
Roche Faucheux, Norco, La.
Louis Hightower, Jayess, Miss.
Jasmer Harvey, Jr., Jayess, Miss.
George Manley Chandler, Jr., 407 Lockhart Drive, Austin, Tex.
William James Davis, Silver Creek, Miss.
William Richard Darden, 206 Jonesboro Road, W. Monroe, La.
Henry John Gueret, Reserve, La.
Truman O. Goodwin, Channelview, Tex.
Plez Ballard, P.O. Box 313, Buras, La.
Moody Edward Flowers, 1818 Maroby St., Houston, Tex.
Henry D. Vicknair Reserve, La.
Greer Ricks, 1918 Constance St., New Orleans, La.
Zolon Ward, Silver Creek, Miss.
Charles L. Harvey, Jayess, Miss.

42. The following persons on board at time of capsizing were lost by drowning:

Fred Elmer Stanford, next of kin, wife, Lora, 1422 W. Crawford Street, Dennison, Tex.

Roche Faucheux, next of kin, wife, Mrs. Roche Faucheux, Norco, La.

Louis Hightower, next of kin, wife, Velma, Jayess, Miss.

Jasmer Harvey, Jr., next of kin, wife, Mrs. Jasmer Harvey, Jr., Rayville, La.

Henry John Gueret, next of kin, wife, Mrs. Henry J. Gueret, Reserve, La.

43. The following persons on board at the time of the casualty are still missing and presumed drowned:

George Manley Chandler, Jr., next of kin, son, Guy Manley Chandler, 407 Lockhart Drive, Austin, Tex.

William James Davis, next of kin, wife, Mrs. William J. Davis, Silver Creek, Miss.

William Richard Darden, next of kin, father, John E. Darden, 206 Jonesboro Road, West Monroe, La.

Truman O. Goodwin, next of kin, wife, Bernice, Channelview, Tex.

44. The following persons on board at time of casualty were injured:

Moody Edward Flowers, shock, nervous disorder of stomach, vomiting blood.

Henry D. Vicknair, shock, water in lungs.

Greer Ricks, shock, leg bruises.

45. Witnesses interviewed:

Lewis Geer, 6325 Harrison Ave., New Orleans, La.
Plez Ballard, P.O. Box 313, Burns, La.
James E. Steele, 245 Central Caldwood, E. Drive, Beaumont, Tex.
Henry D. Vicknair, Reserve, La.
Greer Ricks, 1918 Constance St., New Orleans, La.
Moody Edward Flowers, 1818 Maroby St., Houston, Tex.
Edward A. Whitmarsh, CG Moorings, Pilottown, La.
Charles L. Harvey, Jayess, Miss.
Zolon Ward, Silver Creek, Miss.
E. A. Bullington, 618 Jefferson Park Ave., New Orleans, La.
Foreman J. Naquin, 219 Howard Ave., Houma, La.
Horace Badeaux, Kramer, La.

CONCLUSIONS

46. That the *Drilling Barge Mr. K* capsized because of poor stability conditions including no range of stability that can be attributed to a combination of part of or all of the following factors:

(*a*) Derrick in raised position;
(*b*) An undetermined amount of water in tanks of barge;
(*c*) Cross connecting of the fresh water tanks in barge;
(*d*) Addition of 1000' of 20" casing pipe and over 300,000 lbs. of materials in the mud storage room after arriving on location; and
(*e*) Lack of knowledge of stability by any person on board.

47. That the upsetting force or moment is not known. However, it is felt that the ground swells from SE striking the barge on its beam could well have been the upsetting force. Another possibility is that there were strong upper air winds that struck the derrick and this could be an upsetting force.

48. That the calculations by Mr. Steele as shown in Exhibit No. 8 did not take into account the cross connecting of the fresh water tanks in the hull. When this is taken into account the value of KG becomes 35.67 and GM is only 5.50 in lieu of figures shown on Sheet No. 6 for calculations at draft of 7.6′ F.W.

49. That the *Drilling Barge Mr. K* was designed for inland waters and not for the unprotected waters of the Gulf of Mexico.

50. That the *Drilling Barge Mr. K* is a mobile platform as defined in 33 CFR 140.10–30.

51. That the *Drilling Barge Mr. K* is a manned platform as defined in 33 CFR 140.10–25.

52. That the *Drilling Barge Mr. K* was not subject to the regulations applicable to manned mobile platforms as set forth in 33 CFR subchapter N, since it was less than 3 miles offshore and therefore not on the Outer Continental Shelf.

53. That the persons in charge of the tugs *Madeline* and *Itco II* were not experienced in handling tows such as the *Drilling Barge Mr. K* in the Gulf of Mexico. In addition, both displayed a general lack of knowledge of piloting and the use of a nautical chart when testifying during this investigation. However, there is no willful violation on the part of either person, and there is no action indicated under authority of R. S. 4450, as amended, since neither person was serving under the authority of any license or certificate issued by the Coast Guard.

54. That the Coast Guard assistance, which consisted of conducting air and surface search for survivors, was timely and satisfactory.

55. That there was sufficient lifesaving equipment on board but that none was actually used in this case. The testimony of Plez Ballard on this subject must be disregarded in view of the testimony of the other survivors and witnesses.

56. That the key personnel on board the *Drilling Barge Mr. K* were primarily men well experienced in the oil drilling industry. However, it becomes evident from testimony received that none of the personnel were aware of any hazards or dangers connected with ballasting, deballasting, and operating a vessel such as this drilling barge, particularly in the open waters of the Gulf of Mexico.

RECOMMENDATIONS

57. That the regulations promulgated pursuant to Section 4(c) (1) of the Outer Continental Shelf Lands Act be amended to require plan approval, stability test and inspection during construction of all mobile platforms, as defined in 33 CFR 140.10–30.

58. That mobile platforms in waters beyond the headlands but less than 3 miles offshore be made subject to any regulations promulgated for mobile platforms on the Outer Continental Shelf.

59. That until such time that above recommendations are carried out, immediate steps be taken to require mobile platforms be unmanned when being towed in waters beyond the headlands in order to prevent further loss of life. If this is not practical, it is further recommended that no more than two persons be permitted to remain on board in this situation.

60. That until such time as recommendations 57 and 58 above are carried out immediate steps be taken to require mobile platforms to lower their derricks when being towed in waters beyond the headlands in order to increase the stability of the vessel.

61. That a person with marine engineering experience and a practical knowledge of stability be required to be in charge of mobile platforms when preparing for and moving from one location to another.

JAMES B. RUCKER,
Captain, USCG, Chairman.
EDWARD J. WORREL, Jr.,
Comdr, USCG, Member.
WILLIAM F. REA III,
Comdr., USCG, Member and Recorder.

U.S. COAST GUARD,
April 19, 1960.

COMMANDANT'S ACTION ON MARINE BOARD OF INVESTIGATION; EXPLOSION AND FIRE ON BOARD OFFSHORE PLATFORM SOUTH TIMBALIER BLOCK 134–D1, GULF OF MEXICO, JULY 26, 1959, WITH LOSS OF LIFE

1. The record of the Marine Board of Investigation convened to investigate subject casualty, together with its Findings of Fact, Conclusions and Recommendations has been reviewed.

2. At about 2330, 26 July 1959, an explosion and fire occurred on the Offshore Drilling Platform South Timbalier Block 134–D1, Gulf of Mexico when the well began to blow during the drilling operations. Of the 12 men on the platform, one drowned and two were seriously injured when they jumped from the upper level of the burning platform to the water. Five men suffered varying degrees of burns and four were unharmed. Damage to the rig was estimated to be $300,000.

3. The Offshore Drilling Platform 134–D1, owned by the Gulf Oil Corporation, is a rectangular structure approximately 120 feet by 50 feet having three decks. Atop the platform was Salt Dome Oil Rig No. 10, a two-deck structure consisting of the drilling derrick and living quarters. The living quarters were on the uppermost deck approximately 80 feet above the water surface. The Rig No. 10 had previously been inspected by the Coast Guard in another location as an unmanned platform because at that time the crew was accommodated on an attending vessel. At the time of this casualty 5 of the 12 man crew were being quartered and subsisted on the rig. Rig No. 10 was owned by the Salt Dome Production Company who was under contract to the Gulf Oil Company to drill the well.

4. At about 2330 the crew was drilling at a depth of 4,880 feet when drilling mud began spilling over the top of the mud pit indicating that the well was about to blow. Attempts to contain the pressure were unsuccessful and within a matter of seconds an explosion occurred and the escaping gas touched off. As the flames enveloped the top deck of the platform and the lower deck of the Rig No. 10 the crew began to abandon the structure. Of the men actively engaged in the drilling operation at the time four were able to reach the ladders leading to the boat landing platform and three slid down a four inch rubber sanitary discharge hose to the water when the escape route was cut off by the flame. There were five men in their quarters at the time of the explosion whose escape was blocked when the fire engulfed the single ladder leading from the quarters level to the deck below. All five donned life jackets which were stowed in their quarters and one man threw two or three additional jackets into the water for use by the others. Three men then jumped from the quarters level and the other two slid down the sanitary discharge hose although one fell off part way down. The three who jumped suffered the most serious injuries. The 67 year old cook apparently landed flat and as a result was rendered unconscious and drowned despite his life jacket. The other two entered the water in more favorable attitudes. The injuries were primarily to the chest and back.

5. The radio report of the fire was intercepted by the MV *Rig Service* which was approximately 9 miles away on rig standby for another company. Without awaiting orders the master immediately directed his vessel to the scene and recovered seven men from the water and removed three men from the landing platform of the burning structure. The 11th survivor was picked up from the water by a Coast Guard vessel.

REMARKS

1. The Board found that the explosion and fire resulted from the ignition of combustible gases escaping under pressure of the blowout. Although the source of ignition could not be determined sand abrasions in the bleeder line, hot exhaust lines from the diesel motors or an arc from the operating generators were suggested possibilities. In any event the cause is considered to have occurred solely within the scope of oil well drilling operations.

2. The Board's conclusion that the artificial island composed of the Offshore Platform South Timbalier Block 134–D1 and the Salt Dome Oil Rig No. 10 constituted a manned platform by virtue of the fact that five crew members were continuously living and being accommodated on board is concurred in. In accordance with the board's recommendation the Commander, 8th Coast Guard District is hereby directed to refer the record in this case to the U.S. Attorney having jurisdiction for possible prosecution for the violations of the equipment requirements for manned platforms uncovered by this investigation.

3. The Board's recommendation for amendment to the regulations concerning the definition of artificial islands (46 CFR 140.10–5); means of escape (46 CFR 143.05–1); and the recommended promulgation of a new regulation to provide for additional emergency means of escape for artificial islands will be referred to the Merchant Marine Council for study.

4. The recommendation that the Coast Guard seek legislation to authorize administrative penalties for violations of the Outer Continental Shelf Lands Act (43 U.S.C. 1333) and regulations issued thereunder will be taken under consideration as a possible means of facilitating enforcement.

5. Appropriate recognition of the commendable action on the part of Junius J. LeBlanc, master of the tug MV *Rig Service*, for his part in recovering the survivors will be given.

6. As further recommended by the Board, a copy of the record in this case will be forwarded to the Department of Interior for information.

7. Subject to the foregoing remarks, the record of the Marine Board of Investigation is approved.

A. C. RICHMOND,
Vice Admiral, U.S. Coast Guard, Commandant.

U.S. COAST GUARD,
September 4, 1959.

From: Marine Board of Investigation.
To: Commandant (MVI).
Via: Commander, 8th Coast Guard District.
Subject: Explosion and fire on board Offshore Platform South Timbalier Block 134–D1, Gulf of Mexico, on 26 July, 1959, resulting in loss of life of Claude F. Bulliard, and injury to seven offshore oil rig workers.

FINDINGS OF FACT

1. At about 11:30 P.M., 26 July 1959, an explosion and fire occurred on board Offshore Platform South Timbalier Block 134–D1, Gulf of Mexico, resulting in the loss of life of Claude F. Bulliard and injuries to seven other personnel of the rig.

2. Offshore Platform South Timbalier Block 134–D1 is owned by Gulf Oil Corporation. This platform is located at 28 degrees, 37 minutes, 35.5 seconds North and 90 degrees, 14 minutes, 20.3 seconds West and had been placed in this location on 25 June 1959. A well was being drilled at this location for Gulf Oil Corporation by Salt Dome Production Company. Salt Dome had placed Salt Dome Oil Rig No. 10 atop Platform 134–D1 on about 5 July 1959 and commenced drilling operations on 13 July 1959. Neither the rig nor the platform had ever been inspected by the Coast Guard in its present location. The rig portion had been aboard Platform 132–A during November 1958 at which time an inspection had been made of that artificial island. At the time of that inspection (November 1958), the island was considered as an unmanned platform inasmuch as rig tender *Pelican* furnished accommodations for personnel. In its present location, Platform 134–D did not have rig tender *Pelican* alongside but instead did have persons aboard the rig who, actually and continuously, were living and accommodated thereon.

3. Lateral dimensions of the platform were approximately 120 feet by 50 feet. A general outline of the various levels of this island is shown in Exhibit A to the record. The uppermost level or quarters level is approximately eighty feet above the surface of the water.

4. Weather conditions at the time of this casualty were as follows: wind southeasterly, 15 to 20 miles per hour; clear, dark night, good visibility with seas 4 to 6 feet. Weather conditions had no bearing on this casualty.

5. As a result of this casualty, Claude F. Bulliard, 8324 Panola, New Orleans, Louisiana, male, 64 years of age, lost his life. Mr. Bulliard had been employed by General Marine Catering Service and was assigned to Platform 134–D1 as the cook. Next of kin is Mrs. Claude F. Bulliard, widow, residing at above address. Notification to next of kin was made by employers. At the time of his death Bulliard was apparently in good health.

6. Injured as a result of this casualty were the following men:

Claude W. Gray, Houma, Louisiana—burns on arm, back and foot.

Paul Frederick, Jr., Sunset, Louisiana—burns on face and arms.

Joseph P. Soileau, Villeplatte, Louisiana—burns on face and arms.

Andrew Lee Woodward, Houma, Louisiana—nausea due to swallowing sea water and minor burns.

Abel Vidrine, Jr., Villeplatte, Louisiana—minor burns to face and eyes.

Harvey E. Jones, Gretna, Louisiana—back and chest injury.

Ira H. McPherson, Houston, Texas—back, leg and chest injuries.

7. Of the injured men, the most serious injuries were those suffered by Jones and McPherson. These men were injured as a result of jumping from the quarters level of the island to the water, a distance of approximately 80 feet.

8. On the island at the time of the explosion and fire, there was a total of 12 men. Of these 12, one died, seven received injuries and four escaped unharmed.

9. A about 11:30 p.m., 26 July 1959, a drilling crew of six men employed by Salt Dome Production Company were drilling at a depth of 4,880 feet on the Salt Dome Rig No. 10 located on Platform 134–D. In charge of the drilling crew was Abel Vidrine, Sr. Four of the drilling crew, including Vidrine were working on the rig floor, on which the drilling equipment is operated. Two men, Ernest Thibodaux and Joseph Soileu were working the level below the rig floor called the platform floor.

10. The first indication to any of the personnel of anything out of the ordinary drilling routine was when the drilling mud started to spill over the top of the

mud pit. The derrick man, Thibodaux, who was working in this area, proceeded up the ladder to notify the driller of this but saw that the driller was already aware that the well was "blowing" and was attempting to close the blow out preventers to control the blow. The driller was able to close the uppermost preventer called the hydril. This momentarily contained the pressure but within 2 or 3 seconds an explosion occurred on the platform level in the vicinity of the shell shaker and mud pit (indicated on Exhibit A). Immediately after this explosion the natural gas escaping was on fire and this fire covered most of the platform level and the rig floor. At about this time the driller was also attempting to close the other blowout preventers. The controls for these preventers are located on a single manifold and he succeeded in pulling the lever for one more preventer. However, this preventer, called the blind ram could not close as the drilling pipe in the casing was in its way. The ram did pinch the pipe but could not stop the pressure of the blowout.

11. As the fire enveloped the rig floor and platform level, all personnel on the rig started to abandon the island. Four men in the drilling crew were able to work their way down ladders at the back of the island to the landing platform. The back of the rig is the side on which the quarters are located. The two other men of the drilling crew were able to climb down a four inch rubber hose which was the toilet drain leading from the quarters to the water surface. The tool pusher, Claude W. Gray, who was the person in charge of the platform, had been asleep in the quarters when the well started to blow. He immediately dressed, grabbed a lifejacket and went down to the rig floor. By this time, however, the fire had started and he too, reached the water by climbing down the drain hose. Two other men who were in the quarters when the explosion occurred also used the drain hose as a means of escape.

12. The three remaining men, including the deceased, were also on the quarters level when the explosion occurred. Bulliard, who had been preparing food for the drilling crew when the casualty occurred, started to get some lifejackets out of the locker in the quarters. All persons who were in the quarters did manage to get life jackets on before they abandoned the rig. Bulliard did get life jacket on himself and threw two or three additional jackets over the side for the men who he knew were below and unable to get one. Bulliard then proceeded to jump from the quarters level to the water. He was, however, unable to control himself during this fall of eighty feet and hit the water in a horizontal position face down. He apparently never regained consciousness and as a result drowned with his life jacket on. The other two men who jumped managed to hit the water in a better attitude than Bulliard although both were injured as a result of the jump.

13. Six of the men who abandoned the rig worked their way in the water to a mooring buoy located 200 yards from the platform when they were able to hang on until picked up by the MV RIG SERVICE approximately two hours after the explosion. Three of the men did not have life jackets and were forced to stay on the landing platform of the rig, while it was burning, until they were picked up by MV RIG SERVICE. Two other men stayed in the water, floating free with life jackets on, until they were picked up. One of these was picked up by MV RIG SERVICE. The other was the last man to be picked up, after 3½ hours in the water, by CGC *Blackthorn*. The body of Claude F. Bulliard was picked up by MV *Sinclair Service* and was later transferred to CGC *Blackthorn*.

14. MV *Rig Service*, with master J. J. LeBlanc aboard was on rig standby duty for Sinclair Oil Company near a platform located approximately nine miles north of Block 134. Captain LeBlanc heard the report of the casualty over the Sinclair radio circuit. He plotted the position of the casualty and proceeded immediately, without orders to the vicinity. Upon his arrival at the scene, Captain LeBlanc took ten survivors aboard his vessel. To pick up three of these, it was necessary for Captain LeBlanc to maneuver his vessel alongside the burning rig, with waves 4 to 6 feet present at the time.

15. The fire on the rig was extinguished on the day following the explosion. Monetary value of fire damage to the rig was estimated to be $300,000.00. An inspection of the rig revealed that a bleeder line which led from between two of the blowout preventers to the mud pit had holes in it as a result of sand abrasion when the well was blowing. This line was also found to have all valves open in the line. Drilling operations are carried on normally with this line closed.

16. The blowout preventers had been tested on the rig approximately three days before the casualty and were found to be in satisfactory condition. In the testing of these preventers, it was necessary to open and close the valves on the previously mentioned bleeder line. The Board was unable to obtain any other

testimony as to whether or not these valves were closed or opened at any other time since the test.

17. On the island, two means of escape were available from every level, except the top or quarters level, to the surface of the water. There was only one means of escape from the quarters level to the rig floor. In the usual terminology of the offshore oil industry, however, the quarters would be considered as being on the "rig" which sits atop the "platform" and not therefore a part of the platform.

18. There were no life floats of any type on the structure at the time of the casualty. There were a sufficient number of approved life rings with lights, and life preservers aboard.

19. There was no general alarm system on the structure.

20. There was no system of emergency signals established on the structure.

21. There was no station bill or muster list posted on the structure setting forth the special duties and duty stations of personnel for various emergencies.

CONCLUSIONS

1. It is concluded that the cause of this casualty was the explosion and fire which resulted from well blowing. The explosion had been caused by the ignition of combustible gases which escaped from the bleeder line under the pressure of the blowouts. The Board was unable to determine the exact cause of ignition but concludes that ignition probably resulted from one of the following causes (1) spark caused by sand abrasion in bleeder line as the well started to blow; (2) Hot exhaust lines from either the diesel engines or generators which were running at the time or (3) Arc or spark from the generators which were running at the time or (3) Arc or spark from the generators which were running striking the water in a horizontal attitude.

2. It is concluded that Claude F. Bulliard died by drowning as a result of this casualty. It is further concluded that the primary cause of death must be considered to be the loss of consciousness as a result of falling 80 feet and striking water in a horizontal attitude.

3. It is concluded that although the majority of injured personnel suffered burns of varying degrees, the most seriously injured personnel in this casualty were those men who jumped into the water from the quarters level.

4. It is concluded that, inasmuch as personnel were living and accommodated continuously on the island since its erection, this structure was a manned platform as defined by 33 CFR 140.10–25. Testimony of Gulf Oil Corportation area supervisor indicated that at some level of Gulf's organization it would have been known that personnel were living on the island. There is no question that Salt Dome Production Company was aware that personnel were living on the platform. Supervisory personnel from both companies indicated that it was their intention to eventually operate the platform with the rig tender PELICAN aloneside. This intention, however, cannot alter the status of this island at the time of the casualty, i.e., a manned platform.

5. It is concluded that several violations of Rules and Regulations for Artificial Islands and Fixed Structures on The Outer Continental Shelf (33 CFR 140–146), were noted. These were:

(*a*) There were no approved life floats on the manned platform in violation of 33 CFR 144.01–1.

(*b*) There was no general alarm system on the manned platform in violation of 33 CFR 146.05–5.

(*c*) No system of emergency signals had been established on the manned platform in violation of 33 CFR 146.05–10.

(*d*) No station bill or muster list had been prepared and posted on the manned platform in violation of 33 CFR 146.05.

6. It is concluded that the above noted violations had no bearing on this casualty and none of the effects of the casualty can be considered as a result of any such violation.

7. It is concluded that no failure of any inspected material was involved in this casualty. It is concluded that inspected material, namely, the approved life preservers and life rings actually saved the lives of seven men who were in the water for periods varying from 2 to 3½ hours.

8. It is concluded that there was no actionable negligence on the part of any licensed or documented person, or of any Federal employee, involved in this casualty.

9. It is concluded that presence of only one means of escape from the quarters level to the rig floor cannot be considered a violation of 33 CFR 143.05. This requirement states "at least two means of escape shall be provided for each

manned platform" and further that such means of escape . . . "shall extend from the platform to the surface of the water . . . ." The platform did have two fixed stairways from the rig floor to the surface of the water. As has been previously stated, the terminology of the oil industry defines the platform as the structure upon which the drilling rig and equipment are placed. Using this definition there is no question that there were two means of escape from the platform. Even if the Board were to conclude that the failure to provide two means of escape from the quarters level to the rig floor was a violation, it would also have to conclude that the presence of an additional means of escape would have had no bearing on this casualty.

10. It is concluded that the explosion and rapid spread of fire precluded the use of fire fighting equipment on the platform.

11. It is concluded that the actions of Captain J. J. LeBlanc, master of MV RIG SERVICE, were commendable in that he risked his life and vessel and contributed to the saving of lives. His actions were also commendable in that his actions were prompt and solely on his own initiative.

12. It is concluded that the enforcement of the regulations could be improved by the addition of civil or administrative penalties to the present possibility of criminal prosecution.

13. It is concluded that the violations noted in paragraph 5 must be considered to have been committed by both the Gulf Oil Corporation in the capacity of owner and for whom drilling operations were being conducted and also by Salt Dome Production Company inasmuch as that company was acting as an agent of Gulf Oil Corporation and did have immediate charge of the platform.

14. It is concluded that the presence of an additional emergency means of escape from the top of the island to the water, such as a knotted life line or a wire ladder extending from the platform might have prevented the death and serious injuries which were a result of this casualty. It is noted that in a similar casualty on Offshore Drilling Platform 45–E in the Gulf of Mexico, 15 October 1958, that the Marine Board of Investigation Report dated 4 December 1958 stated "many men received injuries from jumping into the water from a height of fifty or more feet." The possible value of such additional emergency means of escape was clearly shown in this instant casualty by the fact that five men did escape from the platform using a rubber drain hose in the same manner that a life line or wire ladder would be used.

RECOMMENDATIONS

1. It is recommended that the matter of violations by Gulf Oil Corporation and Salt Dome Production Company be referred to the U.S. Attorney for possible action under the provisions of 43 USC 1333.

2. It is recommended that consideration be given to amending 33 CFR 143.05–1 to read "Means of escape shall be fixed stairways or fixed ladders. They shall be constructed of metal and shall extend from each level of the artificial island or fixed structure to the next lower level and from the lowest level to the surface of the water at the low range tidal mark."

3. It is recommended that consideration be given to amending 33 CFR 140.10–5 by adding the following sentence to the present wording "This also includes all fixed or mobile structures such as quarters, drilling rigs or derricks, etc., which are fixed to such building or platform."

4. It is recommended that the matter of additional emergency means of escape for artificial islands be made the subject of a study by the Merchant Marine Council.

5. It is recommended that consideration be given to the possibility of obtaining legislation to authorize administrative penalties for non-compliance with the safety regulations contained in 33 CFR 146.

6. It is recommended that recognition be given to the commendable actions of Junius J. LeBlanc, 208 Railroad (South) Street, Morgan City, Louisiana, master of MV *Rig Service*, by a letter or other appropriate means.

7. It is recommended that a copy of this report be forwarded to the Department of Interior for the information of that agency.

BRET H. BRALLIER,
Captain, U.S. Coast Guard, Chairman.
JOHN F. KETTLER,
Captain, U.S. Coast Guard, Member.
ANTHONY F. FUGARO,
Lieutenant, U.S. Coast Guard, Member and Recorder.

SEPTEMBER 4, 1959.

First endorsement on Marine Board of Investigation report of 4 September 1959.

From: Commander, 8th Coast Guard District.
To: Commandant (MVI).
Subject: Explosion and fire on the SALT DOME PRODUCTION COMPANY DRILLING RIG NO. 10, Gulf of Mexico, 2d July 1959, with loss of life.

1. Forwarded.

CARL B. OLSEN.

STATEMENT SUBMITTED BY THE DEPARTMENT OF THE TREASURY

THE GENERAL COUNSEL OF THE TREASURY,
Washington, D.C., April 3, 1972.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: Reference is made to your letter of March 8, 1972, addressed to Secretary Connally, inviting comments on H–3 of the questions and policy issues related to oversight hearings on the administration of the Outer Continental Shelf Lands Act of 1953.

The cost information requested in question H–3 is not of a nature that this Department is in a position to furnish and we believe it should be obtained from executive agencies more directly concerned, such as the Department of the Interior or the Office of Emergency Preparedness.

Sincerely yours,

SAMUEL R. PIERCE, Jr.,
General Counsel.

STATE OF LOUISIANA,
EXECUTIVE DEPARTMENT,
Baton Rouge, June 19, 1972.

Hon. HENRY M. JACKSON,
Senate Office Building,
Washington, D.C.

DEAR SENATOR JACKSON: Thank you for affording me an opportunity to comment on policies concerning the Outer Continental Shelf now being reviewed by your committee. Attached is our statement with our views listed in alphabetical order, with the exception of answers D–1 through J–2, which express parallel State procedures to Federal. They are generally responsive to those matters set out in your letter of April 14, 1972, to then Governor John J. McKeithen.

I say "generally responsive" because we have been somewhat selective in our answers to the questions propounded. We have, in fact, attempted to confine our efforts to matters about which we feel we have developed experience and knowledge which should benefit your committee. Many of the problems have been adequately defined and explored by others who have previously appeared before you with whom we dealt perfunctorily. Those matters on which we elaborated reflect the views and consensus of Louisiana citizens and State professions who have the experience and discernment to cope with our complex coastal problems. I earnestly invite your attention to the views expressed.

On a final note, we firmly believe in multi-use of our coastal area and the resolution of problems arising from competing interests by cooperation and State supervision rather than outright ban of activity.

Sincerely yours,

EDWIN EDWARDS,
Governor.

STATEMENT ON BEHALF OF THE STATE OF LOUISIANA REGARDING OUTER CONTINENTAL SHELF POLICIES

Question A-5 — What additional changes in the existing legal regime or Federal organizational structure merit Congressional consideration and review?

Answer — At least two major problems long held in abeyance must be faced when the litigation between the United States and the State of Louisiana is settled and the coastline of the State and its seaward boundary fixed.

Background

It is necessary to trace a bit of the history of the Louisiana Tidelands dispute to understand how these problems could be tolerated in former years without any need for an organizational entity or particular legal regime to deal with them. Now the legal construct of the dispute has changed with the result that problems long swept under the rug must be brought forth and made the subject of careful study and action. The two major problems we refer to are the ambulatory boundary question and the matter of conservation regulation, especially the formation of units to avoid the drilling of unnecessary wells in offshore Louisiana near the boundary between State and federal jurisdiction.

In the mid-1950's, the dispute between the State of Louisiana and the United States resulted in a total shut-down of the oil and gas offshore industry. The Supreme Court issued an injunction against both parties preventing any leasing or drilling pending an agreement between the governments. An agreement resulted and was used to partially lift the injunction; it is known as the 1956 Interim Agreement. Under it, the submerged lands of offshore Louisiana were divided into four zones. Zone 1 consisted of a three-mile belt measured from the so-called Chapman Line (a line drawn in 1950 to represent the federal coastline claim). Zone 1 was recognized as within Louisiana jurisdiction. Zones 2 and 3 comprised the disputed area, with Zone 4 consisting of submerged lands clearly recognized as federal.

The result of this arrangement was that as an accidental matter, a large buffer zone existed, a sort of "no man's land", that was to be either jointly administered, or as in Zone 2, not developed or leased at all except to prevent drainage. Consequently, minor, even substantial, changes in the coastline were not likely to pose serious title risks since oil company leaseholders had lease title protection in the buffer zones under the Interim Agreement. Jeopardy to oil or gas leasing or development due to investment insecurity associated with changing coastlines was thus incidentally avoided as a result of the coastline dispute. Also, since no leases could be granted in Zone 2, except under very limited circumstances, the opportunity for drainage and off-set problems to occur has been greatly minimized over the sixteen years that the Interim Agreement has been in effect. The result is that when the litigation is resolved, either entirely or in large part, as is imminent, the buffer effect will disappear. Not a broad disputed zone, but a line will divide the properties that are now declared to be clearly federal or clearly State by the Supreme Court.

The Supreme Court has held that Louisiana has a right to territorial gains which result from accretion. Studies during the 1950's, sponsored by the Mississippi River Commission, showed the tremendously increased flow of the Atchafalaya River during the 20th Century with an enormously enhanced sediment load. It was predicted that the increased sediments would, starting sometime during the 1970's, build a delta land mass projecting 50 miles seaward into the Gulf of Mexico. We speak of a major new land mass that is to grow outward from the mouth of the lower Atchafalaya River through Atchafalaya Bay and into the Gulf of Mexico. Several hundred square miles of land will be added to the State and Nation, according to the best geological minds in this country. Technical consultants who have visited the area have seen new land building in the Atchafalaya Bay area. Already, an inland system of lakes some forty miles long and five or six miles wide, has been filled with sediments. Now the sediment flow that filled the lakes is being carried down to the bay and into the Gulf. This will not only project a great new land mass at the mouth of the Atchafalaya, but geologists have informed us that many of these sediments will be swept westward. Land growth will occur along substantial segments of the western Louisiana coast.

The State of Louisiana lost hundreds of square miles of land during the 20th Century according to studies of the Louisiana Coastal Studies Institute, principally because of activities of various federal agencies. For example, the Army Engineers closed off Bayou Lafourche in 1904 and did major engineering works in the Mississippi Delta which have prevented natural land building forces from balancing land destruction forces such as subsidence and erosion. We are at a moment in time when the major losses to be suffered by these works of the federal government have been suffered, and Louisiana is about to experience, during the 1970's and 1980's, major land building phenomena which should partially offset the severe boundary and land loss inequities it has silently suffered over past decades. Therefore, any approach to resolution of these problems based merely upon a "Let's freeze the boundary" solution would be overly simplistic. However, we do not rule out the appropriateness of considering such an approach in studies to ascertain alternative solutions to the problem of ambulatory boundaries and related title and unitization complexities.

The State of Louisiana will, under the present administration commence studies of potential solutions to these problems. We think until such studies are completed, the Congress should not precipitately act on the ambulatory boundary problem. The Congress should, however, be informed of the existence of this little known and less considered matter of great magnitude. It is, indeed, a matter of tremendous magnitude that cannot be appreciated adequately by those who are familiar only with small rivers and small river actions. We have in Louisiana the mouth of one of the greatest rivers in the world which over the centuries has changed from place to place and created the most unique and complex of coastal environs. Neither the Courts nor the Congress have heretofore adequately provided for the singular circumstances which result from the peculiar geological and ecological realities of the Louisiana coast. Too often these were treated as though it were appropriate to lump the coastal problems of Louisiana with those of other coastal States.

Many extraordinary events testify to the singular character of our coast. In 1837, the Mississippi flooded its banks at Venice and opened a cut known as The Jump, which build more than one hundred square miles of land into the Gulf of Mexico. At another time, the daughter of a French fisherman known as Baptiste Collette cut a little two foot pirogue canal which the river quickly enlarged and used to build scores of square miles of land into the Gulf. Elsewhare, as bayous were closed artificially or naturally, great masses of lands have fallen back into the Gulf. So, when we speak of the big changes that are coming at the Atchafalaya Bay and which will continue to occur in the Mississippi Delta, there is much in our coastal history that supports this prognosis.

Ambulatory Boundary Recommendations

But what does this have to do with the question of whether there is a need for change in the existing legal regime or federal organizational structure? We think it indicates that the problem of the ambulatory boundary is so large, so complex and so fraught with need to carefully consider the equities as they may relate to many problems, that there should be special and substantial study by both the federal and State governments to ascertain appropriate changes in law and administrative structures. Many matters are affected: revenue sharing, title security for the oil and gas industry to protect and encourage investments, relationship to unitization to reduce the number of wells that would otherwise have to be drilled, future jurisdictional needs other than for oil and gas development over the great new Atchafalaya Delta, ecological and economic impact, and planning for resource utilization of the great new swamp lands to be built, and legal problems of avoiding future State-federal conflict.

We plan to seek the cooperation of affected State agencies and scientific and legal specialists in Louisiana to consider these problems and, after appropriate technical studies, to seek cooperation with federal agencies in developing recommendations to the Congress for its consideration and review. In our judgment, the Congress should in the meantime support studies to deal with this matter. However, the technical character of the problem, its uniqueness to the Louisiana situation and the greater intensity of oil and gas development along the Louisiana coastal zone warrants that this matter be intensively studies separately from the broad hearings dealing with the Outer Continental Shelf problems of the entire United States coast. In short, it is our recommendation to this Committee that it recommend that further hearings be held specially dealing with the highly changeable character of the Louisiana coast and the ambulatory problem posed by the Supreme Court's 1969 decision in United States vs. Louisiana, if negotiation between the Executive Branches of the Louisiana and the federal government do not result in early resolution of the problem.

Conservation Problems and Recommendations

Sound oil and gas conservation regulation is required for many reasons: to prevent inequities in the development of oil and gas properties; to minimize adverse ecological impact; to maximize recovery of important resources in the most practical and economic fashion. It is in the interest of the industry and the public to have no more drilling than is necessary to efficiently and economically drain these underground resources. The Louisiana Mineral Board and the Louisiana Department of Conservation, in their dealings with counterpart federal agencies, have always sought to cooperate fully in the development of unitization agreements or other plans for development of resources along boundaries. They have sought to encourage efficient and economical development that would yet serve the equitable interests of each government participating in revenues from pools that might underlie both sides of a boundary or potential boundary. The experience has been less than satisfactory. The federal government refuses to negotiate at higher levels and insists upon having negotiations conducted by low level officials subject to one-sided review by higher federal authority. Consequently, any understanding by Louisiana officials with federal officials can seldom be relied upon and years later may be reversed by the higher federal authority. Louisiana is unable to obtain direct negotiation between higher State and federal authorities. Years are consumed and still agreement is not reached in final form on the few locales where development has been at the edge of and on both sides of the Zone 1-Zone 2 boundary. In December of 1971, great stretches of the Louisiana coast were adjudicated by the Supreme Court on one side of the line and we expect that a decree will be rendered this year adjudicating title on the other side of the line, causing clearly adjudicated State-federal areas to bound each other with the multiplication of drainage, off-set and unitization problems that are sure to develop. A quasi-adjudicative agency should be established, with joint federal-State representation thereon to create a mechanism for Louisiana to have "it's day in Court" on unitization and conservation problems. Otherwise, the absence of agreement and interminable years of unsuccessful negotiation is apt to be repeated at scores of locations along the Louisiana coast with great injury to the State of Louisiana that could only be rectified by the State making demands upon its mineral lessees to drill wells to off-set wells on the federal side of the line. These were the very problems that, in the early days of the oil industry, caused lands to be peppered with derricks unnecessarily and with tremendous economic and geologic waste.

Louisiana believes that if the federal officials responsible for unit negotiations know that there is an independent agency or an independent arbiter available to fairly and objectively consider the claims of the State as to geologic and petroleum engineering problems affecting unit questions, these federal officials will be more apt to promptly agree on reasonable voluntary plans for units. Actual resort to hearings before such an adjudicative body might well prove unnecessary in most instances.

If equity cannot be served by the creation of such a body to either arbitrate or adjudicate adversary proceedings between State and federal technical agencies, the result will be an unfortunate proliferation of unnecessary wells, financial burdens on the industry and higher prices for oil and gas. However, again this is in an area where ill-considered action could defeat desired ends. The subject matter is interrelated to complexities of the ambulatory boundary problem which, as we have earlier suggested, is a matter that in itself, should receive the most careful expert attention. We recommend therefore, to this Committee that it take note of the need for legislation on this important problem now and the realization that such need will increase in the future. After technical studies, we have initiated are completed, Louisiana expects to come back to the Congress with specific recommendations and hopefully gain the concurrence of the administration on the proposals Louisiana will submit.

Question G-4 — What should the role of the State government be with respect to Federal decision-making concerning:

Answer — (a) Exploration?:

The States should have a very active role in Federal decision-making concerning exploration on OCS lands bordering the States' jurisdiction. In order to accomplish this, special policies should be developed by a joint State-Federal effort with regard to such matters as drilling regulations, the spacing or density of wells, production allowables, production handling and unitization procedures. Louisiana has long played a significant role in regulating seismic exploration in offshore areas. By agreement with the Department of the Interior, the State of Louisiana develops, promulgates and enforces all regulations to the edge of the OCS for the protection of fishing areas in Louisiana and on the OCS.

(b) Leasing? :

The States should be informed about Federal leasing proposals and have the opportunity to approve or oppose the leasing of certain areas. There have been instances in Louisiana when agreements were worked out with the Federal Government whereby leasing and exploration in specific areas would be programmed so as not to interfere with peak shrimping seasons. These agreements were based on shrimp population dynamics research made available by the State.

(c) Environmental regulations on OCS lands bordering the States' jurisdiction? :

The States have what may be termed an overriding interest in Environmental regulations on OCS lands bordering the States' jurisdiction. The States are probably in a better position to either develop or evaluate environmental regulations in their coastal waters and on the adjoining OCS since, generally, they have a greater amount of scientific information on the local ecosystem. Because of this, we would strongly recommend that Environmental regulations developed for the OCS be thoroughly coordinated with and approved by the border states.

Question G-5 Are there high priority research or administrative programs related to OCS administration that remain unfunded, underfunded, or short of personnel?

Answer Without question, a considerable amount of high priority research should be directed to determining the effects of chronic oil pollution and localized accidental spills. While present fishery production in Louisiana would indicate that serious toxic effects from oil do not occur, this question is still largely unanswered and must be answered before unlimited mineral exploration can be condoned throughout the ocean areas. Additional work is also needed to determine the effects of buried and unburied pipelines. At the present time, it appears that it will be very difficult to bury pipelines in water depths beyond the two hundred foot contour line. Thirdly, if dispersants or other types of chemical control of oil pollution is advocated, a considerable amount of bioassy work is needed to determine whether the toxicity of such chemicals alone or in combination with oil is more detrimental to the environment than oil alone.

Question I-2

In light of existing and projected demands for energy and the simultaneous requirements to protect the marine environment, what alternative sources of energy other than OCS petroleum from future leases are readily available and at what economic costs and environmental risks?

Answer

With regard to Louisiana, the most objective and far reaching method of obtaining alternative sources of energy, other than leasing of the OCS, would be increased onshore private exploration for oil and gas which should be encouraged by permitting a general rise in the price of crude oil which we consider depressed as compared with other products except natural gas. While such a price rise would obviously be eventually borne by the consumer, it offers a practical means of halting the declining rate of exploratory effort and encouraging additional drilling for onshore reserves that are badly needed.

Regarding natural gas, the greatest possible incentive to achieve accelerated exploration that could be given to the oil and gas industry and indirectly benefit the consuming public would be to remove the FPC price restrictions entirely and let the price of gas seek its natural level. The renewed interest in exploratory drilling not only would result in substantially increased reserve of gas, but it would also increase oil production substantially. Again, the resulting cost increase to the consumer would more than be overcome by the insurance to them of a reliable and steady domestic supply of natural gas.

Question I-3

What would be the economic, security of supply, and environmental consequences of alternative strategies for the scheduling of OCS resource development (e.g. postponing development and consumption of these resources until the need for them is greater, due to increased costs or unavailability of imported oil)?

Answer

The postponing of development and subsequent non-consumption of optimistically assumed resource reserves, until such time as imported oil becomes unavailable or the cost of such oil becomes prohibitive would be impractical for several reasons:

(1) The United States would be at the mercy of unfriendly powers in the Middle East and Africa where more than 75% of the known world reserves of oil are located.

(2) Technical and professional personnel and operational equipment would be lost to foreign operations or assimilated into other industries thus destroying the domestic oil and gas industry. This would have a catastrophic effect on the economy. Once this nation postpones development and the domestic industry loses the expert and skilled labor force and the necessary drilling equipment to other nations, it would be virtually impossible to again start up the industry, and the lead-time that has been developed over the years will have vanished forever.

(3) Training centers would be lost and educational endeavors curtailed.

(4) Research would virtually terminate.

(5) National security would be endangered as no immediate source of energy would be available in the event imports should suddenly cease. As an illustration, the country as a whole was unable to meet the demands placed upon it by withdrawal of Eastern Hemisphere oil during the Suez Canal crisis in 1956. What shut-in capacity we had at that time has largely disappeared in the intervening 16 years. Today's shut-in capacity is insignificant. National security demands that domestic sources be developed to the greatest extent possible.

(6) Environmental damage or oil spill pollution would still be a major concern due to the tremendous amount of imported oil being brought in by large tankers.

It is imperative that an orderly development onshore and offshore continue at least until such time in the future as alternative sources of energy, such as nuclear or solar, can be economically generated.

Question J-1 — What are the nature and magnitude of environmental risks and problems related to OCS oil and gas development in:

Answer — (a) Geophysical exploration:

Historically, geophysical exploration has been accomplished through recordings of refracted sound vibrations derived from under-water explosions. The detrimental effects to the environment as well as the flora and fauna are apparent. We realize that a series of under-water explosions in the Gulf of Mexico is probably insignificant when compared to natural disasters, but it is very possible that these shock waves disrupt the spawning of some of our commercially important species. The impact of such a catastrophe on the states' economy would be incalculable and not worth the risk, since alternate methods appear available.

Recent innovations of seismic instrumentation and exploration indicate that seismic profiling can be accomplished utilizing a much less destructive sound source. Seismic exploration should be limited to these alternate sources.

(b) Drilling and Production

All of the environmental risks involved with drilling and production are not known since the toxic effect of oil in the ecosystem is not clear. However, several problems that may be of immense magnitude to the environment are recognized:

Accidental and Chronic Pollution:

Accidental pollution can be disastrous, costly, create great public concern, and cause spectacular short-term local environmental disruption. Conclusions that may be drawn concerning the effects of accidental pollution include the following:

1. There is little or no evidence that accidental oil pollution has a gross permanent effect on the ecosystem. Whether minor or accumulative effects occur have not been demonstrated.

2. Even when loss of animal or plant life occurs, in time, recovery of the environment is followed by return of normal populations. In most cases the recovery time is not prolonged.

3. The principal problems resulting from accidental oil spills involve these factors:

   a. Contamination of filter-feeding animals

   b. Heavy fouling of beach or marsh areas; and the coating of birds, animals and plants in local areas.

   c. Fouling of private property and the cost of cleanup procedures. Chronic pollution by contrast, is a more critical and less understood problem. Prior to increased state regulation and surveliance of the oil industry continuing low-level pollution associated with intensive oil production in shallow inshore embayments and marsh areas was common in Louisiana. Production from numerous wellheads, with associated gathering lines, tank batteries, separators and sludge pits all afford opportunity for leaks and spills causing chronic introduction of oil into the ecosystem. There were areas of intensive petroleum production where chronic oil loss had ruled out other uses of the area, destroying once valuable oyster reefs and shrimping grounds. However, the onset of stricter state safety regulations as well as company initiated safety precautions have led to the installation of additional safety equipment and oil spills have been kept to a minimum in recent times. It has been our experience that oil and gas operations can be conducted with only minimal interference to other users of our bays, marshes and offshore areas and there is no reason to believe the OCS cannot enjoy the same multiple uses.

Oil Emulsion Muds:

One of the most serious and long-lasting types of pollution associated with the petroleum industry occurs when diesel oil is added to the mud system to enhance the drilling of deep wells. If the excess or used mud or cuttings from such an operation is lost overboard, there results a serious oil pollution of the substrate since the oil is absorbed into the heavy mud particles and settles to the bottom. Visible oil slicks may not occur and the pollution may go undetected. If oysters or other filter-feeding animals are in the area, they soon filter out and concentrate the oil and develop an unpalatable oily taste. As little as five hundred parts per million of oil in mud will cause serious problems in oysters and even one part per million added to a running-water system will be concentrated by oysters kept in the system for several weeks.

Detergents, Dispersants and Other Chemicals Used to Clean Up Oil Spills:

Usually when oil spills occur, public outcry and concern on the part of the industry to reestablish good public relations result in rapid and costly attempts to clean up the area or to make the visible oil disappear from sight. From our experience with oil emulsion muds, this may be the worst approach possible to the cleanup problem for these reasons:

1. Detergents or dispersant chemicals may cause the oil to absorb on mud and silt particles which sink to the substrate or float in the water column where they are more available to filter feeders.

2. Absorbed oil on the bottom particles appears to take longer to degrade.

3. The use of chemicals to disperse the oil involves placing an additional load of foreign and undesirable material in the ecosystem. Many of the dispersants tested proved to be fare more toxic than oil.

4. Dispersal of oil does not allow proper mapping or study of polluted areas.

5. Floating oil is probably the least damaging position for oil to occur in the ecosystem. Here it degrades more rapidly --its only effect is at the interface and, except in intertidal areas and marshes, will usually dissipate, degrade and be mechanically dispersed by wave action with little apparent effect on the ecosystem.

Commercial Fishery Problems:

Offshore operations have created several types of problems for commercial fishermen, particularly shrimp tralwers. The principal difficulties for fishing fleets involve navigational problems and seabed obstructions. The producing platforms and other above-water structures are well marked and lighted but when they become extremely numerous, significant fishing area is lost. Occasionally boats collide with structures but the primary problem seems to be that, with fishing gear down, they must stay well clear of the rig in order to avoid possible collision or the entanglement of gear in underwater material discarded from the rig. This means that a considerable area around each site cannot be safely fished and significant fishing area may be lost to them.

Until recently underwater completions and inactive stubs were a serious problem. These obstructions, if in water greater than eight feet above their highest point, do not have to be marked or bouyed. More than two hundred such structures clutter the sea floor off Louisiana and this has resulted in the loss of a considerable amount of expensive fishing gear. New rule changes now allow the pipes to be cut off below the mudline and it is expected that most of these hazards will be removed within the next year or two.

(c) Undersea pipeline construction and operation

Undersea pipeline construction and operation is not a serious environmental problem if regulated to prevent exposed pipes on the seabed. Usually subsurface currents will alleviate the problem by burying pipelines. New construction is a potential hazard to commercial fishermen and has resulted in gear loss.

(d) Tanker operation

The overall damage from a tanker spill is probably minimal if it occurs offshore and remains away from the coastal marshes. With the advent of super-oil tanker ports which will concentrate these large vessels in a near offshore area, the possibility of vast oil spills, constant leakage, and accumulation of minor spills is tremendously enhanced and this poses a great threat to the environment in these areas unless closely regulated.

(e) Onshore pipeline construction and operation.

Highest priority should be afforded to the prevention of alteration of the environment in inshore pipeline construction and operation. Some of the related problems are:

1. The dredging and channelization needed for the navigation of drilling rigs to location result in direct destruction and loss of nursery areas from dredging, silting, leveeing and erosion. Sessile animals and bottom organisms are killed or dislocated while marsh areas may be destroyed, drained and drastically altered.

2. Pipeline construction can be especially destructive and result in serious ecological changes. The construction of large and long pipelines requires the dredging of wide and deep flotation canals for the laying equipment. These canals, 40 or more feet in width traverse and cut through marshlands and embayments without regard for changes in the natural drainage pattern, the disruption of currents in bays or waterflow in marshlands, and the direct loss of animals and plants within the rights-of-way from dredging and silting. Long-range effects involve serious erosion of unstable marshes traversed by such canals.

3. Even in cases when dredging is not a factor, shorelines, intertidal areas, marshes and very shallow waters which make up an important part of the ecosystem can be cut up and destroyed by vehicular traffic such as mudboats, marsh buggies, tugs and equipment barges and other heavy equipment.

4. More widespread and serious ecological damage and disturbance of the ecosystem occur from the indirect and secondary effects of the above activities. The more direct effects are local in nature and are generally in or near the rights-of-way while the indirect effects are more far-reaching and difficult to evaluate. These include:
   a. Changes in water cycling rates and volumes;
   b. Sale and freshwater intrusion;
   c. Indirect silting considerable distances from the site of activity resulting from changes in the direction and velocity of currents;
   d. Partial or total disruption of normal drainage patterns and water movements.

Question J-5: What quantitative information is available about the total costs of past mishaps on the OCS, including oil and gas lost, private and government cleanup costs, loss of fish and wildlife, damage to tourism, reduced property values, and administrative costs?

Answer: Losses to fish and wildlife in the Louisiana area has not been demonstrable nor has any data been presented which statistically supports evidence of economic losses. The administrative costs to the State of Louisiana for surveillance, research and additional workload during times of serious accidents has been considerable, probably exceeding several hundred thousand dollare per accident.

Question J-7: What additional geological, biological, engineering or other information is necessary with regard to improving the environmental safety aspects of offshore oil and gas operations? Is there research that ought to be completed before any further offshore leasing? Are there specific instances or areas in which leasing should be postponed pending completion of further studies? What time, effort and costs would be involved in this research?

Answer: We are of the opinion the studies that have been completed and the environmental safety aspects presently required through Federal OCS rules and regulations are sufficient. The State would continue to cooperate and encourage new and improved safety devices, where reasonable, in order to further protect the environment. Leasing, exploration and development should not be postponed to await completion of research projects or studies.

Question K-2: Should the Congress determine, on a case by case basis, the circumstances under which tracts of OCS lands should be established as marine preserves or sanctuaries?

Answer: Whether established by Congress, or other authority, we agree that these must be considered on a case by case basis. However, any establishment of a marine preserve or sanctuary should be considered under the multiple land usage concept which includes petroleum exploration and development. The State of Louisiana has years of experience, which has been documented, in the exploration and development for oil and gas associated with perserves or sanctuaries. Under the specific rules and regulations established for similar State areas, multiple use has, does and can exist. Prime examples of these are: (1) Avery Island Bird Sanctuary and Scenic Gardens, (2) Pass-a-Loutre Game and Fish Preserve, (3) Rockefeller Wild-Life Refuge and Game Preserve and (4) Russell Sage or Marsh Island Wild Life Refuge and Game Preserve.

Question K-3: Are there instances in which highly promising OCS acreage should be permanently reserved from development for recreational, ecological, or aesthetic reasons? What cost-benefit standards should be applied to proposals for reservations of this type? What other standards or considerations should be applied to proposals for reservations of this type?

Answer: We feel reasonably certain that some areas should be set aside for permanent recretional and ecological reasons. Many such areas could probably be located in areas where mineral production does not occur. A real problem does exist in Louisiana where vast mineral resources underlie a unique and extremely valuable fishing area. Setting aside this area for the fishery purposes along probably could not be justified in view of the tremendous oil reserves involved. However, if the fishery and natural resources production of the Louisiana coast is destroyed because of mineral production, the long-term economic loss to the country would be staggering and the loss of food and nutrients to a growing human population would be incalculable. In view of this, exceedingly careful regulation of the area should be undertaken and probably some cutoff point in mineral exploitation should be determined beyond which this highly productive area would not be subjected to further ecological dangers. This problem, however, really lies in the nursery grounds and coastal areas well within Louisiana's jurisdiction and does not constitute a major problem on the outer continental shelf.

Question K-5: If a short term (two-year) or long term (five-to ten year) moratorium were established and all OCS operations were suspended:

(a) From what probable alternative sources would petroleum demand be filled?

Answer: For the short term (two-year), we see no alternative source for petroleum demand except from foreign sources. The lead time to develop new resources in this country varies from five to seven years for conventional fuels. The same answer would prevail for the long term (five-to ten-year). The lead time for developing other forms of energy as alternatives, the so-called exotics, would require from 10 to 20 years.

(b) To what extent, if any, would these alternatives reduce the risk of coastline oil pollution?

Answer: The only alternative, as indicated in the answer to K-5 (a) above, is increased use of foreign oil. Rather than reduce the risk of coastline pollution, we believe the risk would be <u>increased</u>. Statistics are available which indicate that tanker leakage and spillage from accidents on the high seas cause a major portion of coastline pollution. If more foreign oil is transported to our shores by tankers, then we believe the risk would be materially increased.

(c) What new environmental risks would be associated with alternative sources of supply?

Answer: The answer to K-5 (b) we believe also answers this question. We know of no new risks. The risks would only change in location.

Question E-1: What is the procedure currently used by the State (Federal) agencies for determining, on a short range (one year), intermediate range (five years), and long range (five years and beyond) basis:

(a) The demand or need for OCS production?

Answer (a): Realizing the natural gas shortage, the State Legislature in 1970 adopted an Act to allow the State to take its gas in kind. Implementation of this Act is being considered at this time.

Question E-1 (b): The sequence, size and timing of sales? and (c) The location, size and shape of specific tracts offered for lease?

Answer (b)&(c): Sales are presently being conducted on a monthly basis. The number of tracts, location, total acreage, size and shape depends upon nominations by industry although by statute a single tract may not exceed 5000 acres. The State Mineral Board has authority to advertise for lease any specific acreage on its own initiative. Thirty-five years of experience has proven that sales conducted at regular intervals is conducive to the orderly development of oil properties. Regular scheduling of sales has many advantages; it enables the industry to budget properly, grants it security in planning, and affords time in which to secure proper equipment.

Question E-1-A: What is the procudure currently used by Federal agencies for determining on a short range (1 year), intermediate (5 years) and long range (5 years and beyond) basis:

(a) The demand or need for OCS production?

Answer: With respect to Louisiana operations, crude demand is determined on a monthly basis through nominations from all crude purchasers in the State. In the past, determination of intermediate or long range demand could only be ascertained through an extrapolation of demand trend. However, this is no longer valid as Louisiana can not satisfy the current market demand even at maximum productive capability. Louisiana's market demand for June, 1972 is 1, 519, 304 barrels per day. June allowables have been assigned so as to produce an estimated 1, 314, 000 barrels per day, or about 205, 000 barrels per day less than market demand. Our best estimates of all out production capability for Louisiana would leave us far short of the current market demand.

Several years ago we were producing at much lower rates in response to lower market demand and therefore had a reserve producing capacity of sizeable proportion. This was demonstrated by our ability to produce an additional 250,000+ barrels of oil per day to satisfy the increased market demand during the 1967 and 1970 Middle East Crises. Louisiana cannot produce any appreciable amount of oil today to carry us over a national emergency of any proportion. For the above reasons, market demand no longer plays an important role in influencing Louisiana's production. Future production rates in Louisiana will be controled by reservoir capabilities.

Question E-2: What is the procedure currently used by the State (Federal) agencies for taking into account recreational, fish and wild life and other environmental values in choosing tracts to be leased?

Answer: The State has specific rules and regulations governing exploration and development of game preserves, fresh water supplies, and oyster beds. Public authorities or public bodies are notified when these sensitive areas are advertised for leasing, and close cooperation with all related agencies is maintained with supervision imposed.

Question F-1: What, in general, are the current procedures for lease supervision and inspection? Are there concrete indications of improved surveillance and compliance over past experience? To what extent has the risk of accidents, such as those which occurred near Santa Barbara and Offshore Louisiana been reduced, and to what factors are reductions (if any) due?

The Louisiana Department of Conservation exercises the police power of the state through extensive regulatory supervision. The Department is divided into six (6) districts, four of which border on the Gulf of Mexico. These districts have a total of twelve oil and gas inspectors assigned to fields in the bay areas and Zone I. They are responsible for the testing of wells, plugging and abandonment operations, casing tests, and platform inspections to insure compliance with Statewide Order No. 29-B which includes pollution surveillance regulations. The work of our oil and gas inspectors is supplemented by agents from the Inspection and Enforcement Division who make investigations and file detailed reports on production platforms and salt water disposal facilities in all fields at least once a year. Re-inspections are made upon the request of the local district managers or when otherwise appropriate. This method of operation has brought about more accurate reporting of production data and oil spills, induced cleaner operations and encouraged the installation of devices to reduce pollution. Spill pans under production vessels with drains to collecting sumps and pumps with automatic controls have been installed. This equipment is checked at regular intervals to insure that it will operate when needed.

Holes in the impervious platforms have been repaired along with broken retaining walls to insure that any spillage which occurs in everyday operations will not cause pollution. The efficiency of separation has been increased and the amount of entrained oil, formerly discharged with produced brime to the Gulf of Mexico, has been or is being reduced to meet new water quality standards. The accidents which occurred near Santa Barbara and offshore Louisiana caused the oil and gas operators along with the Louisiana Department of Conservation to re-evaluate their operations and pollution prevention requirements. Some companies established inspection teams, dispatched them to inspect their installations, and acted on their recommendations to reduce the possibility of similar accidents. Others set up waste oil salvage operations whereby waste from bilges, sumps, stock tanks, production vessels, etc., is picked up at regular intervals by barges and brought inshore for non-contaminating disposition. Equipment to contain and dispose of oil spills has been stocked in strategic locations. Funds for their purchase was provided by different companies for use on a cooperative basis by operators in an emergency. All of these factors have considerably reduced the quantity of oil which was formerly discharged to the Gulf accidentally or otherwise.

Question G: (a, b, and c-11) What jurisdictional issues remain unresolved regarding:

(a) The seaward limits of the OCS?

Answer: The question of where the Outer Continental Shelf ends in one that continues to divide international law experts. We wish merely to clarify the attitude of the State by means of a general policy observation.

Proposals to either internationalize or submit to international control what is presently considered the Outer Continental Shelf, a vital area of important natural resources upon which so many Louisianaians depend for their livelihoods, will be strongly opposed by the people of this state. We disapprove of any such proposal which decreases State or National jurisdiction over our offshore submerged lands.

(b) The seaward limits of state jurisdiction?

The seaward limits of State jurisdiction are still the subject of litigation between the State and Federal governments. A Special Master appointed by the Supreme Court conducted extensive hearings over two years, and extensive briefs are now being written on the many complicated matters in dispute. Islands and low water elevations questions, cartographic and survey problems, natural entrance point selection tests, water area bay tests, and many, many other factual and legal questions complicate the dispute. It is not unlikely that another three to five years will be required to resolve the matter.

To here list and discuss the issues involved would be impossible but major points at issue include those itemized on a statement of the issues which the parties have agreed remain to be decided by the Special Master. (Appendix A attached).

We have heretofore commented in response to question A-5 concerning problems of the ambulatory boundary in a major deltaic coastal area. Unless agreement is reached on that problem, litigation is apt to be renewed after the present dispute is resolved.

(c) The authority of the Secretary of the Interior

(11) to promulgate "conservation" regulations?

Answer: As to the authority of the Secretary to promulgate conservation regulations, such authority does not and should not affect areas owned by the State or subject to State leases. As earlier noted, this emphasizes the need for an agency or arbiter, independent of the Secretary's power, to resolve State-federal boundary disputes. The creation of such a body should be given serious consideration. It could, perhaps, be composed of State and federal representatives and invested with powers to enact conservation regulations for boundary areas.

Question I-1: In view of the recent Louisiana Offshore sale court decision, what changes in procedure, if any, do the State agencies contemplate to satisfy NEPA environmental impact statement requirements?

Answer: We feel the National Environmental Policy Act of 1969 should be re-evaluated in light of the present energy crisis. Interpretation or clarification of certain segments must be made so that the petroleum industry can function. Individual impact statements on each tract is impractical if not impossible. An impact statement that is prepared covering a specific area should be sufficient for any future petroleum development activity in that particular area and repetitive individual impact statements on portions covered by a previous statement should not have to be submitted. These areas should be classified and identified with similar environmental aspects as the controlling factor. This is necessary to allow industry to operate as efficiently and effectively as possible from the beginning of the exploration activity to actual drilling and production operations. Experience has proven that it is possible and realistic to have consistent rules and regulations governing those areas with the same or similar environment conditions.

No. 9, Original

IN THE SUPREME COURT OF THE UNITED STATES

October Term, 1969

UNITED STATES OF AMERICA, PLAINTIFF

v.

STATE OF LOUISIANA, ET AL.

BEFORE THE SPECIAL MASTER

JOINT PRETRIAL STATEMENT

ERWIN N. GRISWOLD,
Solicitor General of the United States.
JACK P. F. GREMILLION,
Attorney General of Louisiana.

The United States and the State of Louisiana jointly submit the following pretrial statement:

Part A sets out the issues that the parties now believe are before the Special Master under the Supreme Court's order of May 19, 1969. This statement is arranged in geographical sequence according to the areas affected by the various issues, proceeding from east to west. Under each area are stated the issues that affect it; where such an area includes smaller areas affected by particular issues, the smaller areas are listed after the larger area, with the issues affecting each. Although the questions are stated unconditionally, it is understood that in a number of instances the parties propose them alternatively.

Part B states the understanding reached regarding geographical facts.

Part S contains suggestions regarding procedure.

A

1. From Errol Shoal to the western headland of Sandy Point Bay. (U.S.C. and G.S. Charts Nos. 1270 and 1272; Maps 6–7 of 41 and 1–7 of 8, La. Ex. 119 pp. 6–14.)

(a) Did actions of the United States prior to this suit have the legal effect of utilizing straight baselines to delimit inland waters?

(b) Have changes in geographical configurations divested Louisiana of title to any submerged lands in this area?

(c) Have changes in law divested Louisiana of title to any submerged lands in this area?

(d) Does this area include any historic inland waters under principles of international law, particularly at Isle au Breton Bay, East Bay or West Bay?

(e) Does this area include any historic territorial waters under principles of international law, particularly at Isle au Breton Bay, East Bay or West Bay, and if so, what is the effect?

2. From Dead Woman Pass to North Pass. (U.S.C. & G.S. Chart No. 1272; Maps 1 and 2 of 8, La. Ex. 119 pp. 8–9.)

(a) Are there islands or low-tide elevations that should be considered part of the mainland?

(b) What closing line meets the semicircle test?

3. From Pass a Loutre to Southeast Pass, including Blind Bay. (U.S.C. & G.S. Chart No. 1272; Maps 2 and 3 of 8, La. Ex. 119 pp. 9–10.)

(a) Are there islands or low-tide elevations that should be considered part of the mainland?

(b) If the closing line of Blind Bay affects the three-mile limit, where are the natural entrance points between which the closing line should be drawn?

(c) Should islands or low-tide elevations be regarded as forming separate mouths of a bay if one or more direct lines could be drawn between other natural entrance points of the bay so as to run wholly landward of such islands or low-tide elevations?

(d) Are there islands or low-tide elevations at Blind Bay that form separate mouths to it?

4. From Southeast Pass to South Pass, including Garden Island and Redfish Bays. (U.S.C. & G.S. Chart No. 1272; Maps 3 and 4 of 8, La. Ex. 119 pp. 10–11.)

(a) Which islands or low-tide elevations off Southeast Pass should be considered part of the mainland?

(b) Should islands or low-tide elevations be regarded as forming separate mouths of a bay if one or more direct lines could be drawn between other natural entrance points of the bay so as to run wholly landward of such islands or low-tide elevations?

(c) Are there islands or low-tide elevations off Southeast Pass that form such separate mouths of the Garden Island-Redfish Bay complex?

(d) Where are the natural entrance points of the Garden Island-Redfish Bay complex?

5. South Pass. (U.S.C. & G.S. Chart No. 1272; Map 4 of 8, La. Ex. 119 p. 11.)

(a) What are the means of proof recognized by the Convention on the Territorial Sea and the Contiguous Zone for ascertaining whether particular elevations are above the level of mean low water?

(b) Does the Convention on the Territorial Sea and the Contiguous Zone control the kind of evidence that may be introduced in this case to identify low-water lines?

(c) Is Louisiana entitled to submerged lands measured from such islands or low-tide elevations as shown on Chart No. 1272 irrespective of evidence to the contrary?

(d) Where are there islands or low-tide elevations off the mouth of South Pass?

(e) Have there been changes in the coast line that would affect the future distribution of revenues heretofore accrued since June 5, 1959, and, if so, when did the changes become effective?

6. From South Pass to Southwest Pass: East Bay. (U.S.C. & G.S. Chart No. 1272; Maps 4–6 of 8, La. Ex. 119 pp. 11–13.)

(a) What are the means of proof recognized by the Convention on the Territorial Sea and the Contiguous Zone for ascertaining whether particular elevations are above the level of mean low water?

(b) Does the Convention on the Territorial Sea and The Contiguous Zone control the kind of evidence that may be introduced in this case to identify low-water lines?

(c) Is Louisiana entitled to submerged lands measured from such low-tide elevations or low-water lines as shown on Chart No. 1272 adjacent to South Pass but not shown on Map 4 of 8, irrespective of evidence to the contrary?

(d) Are there low-tide elevations or low-water lines in East Bay adjacent to South Pass not shown on Map 4 of 8 but shown on Chart No. 1272?

(e) Have there been changes in the coast line that would affect the future distribution of revenues heretofore accrued since June 5, 1950 and, if so, when did the changes become effective?

(f) Within East Bay, are there any bays as defined by Article 7 of the Convention on the Territorial Sea and the Contiguous Zone and, if so, where are their natural entrance points?

7. From Southwest Pass to Belle Pass: Ascension-Caminada-Barataria Bay complex. (U.S.C. & G.S. Charts No. 1272, 1273 and 1274; Maps 6–8 of 8 and 8–14 of 41, La. Ex. 119 pp. 13–22.)

(a) Is part or all of this area an overlarge bay as provided for by Article 7 of the Convention on the Territorial Sea and the Contiguous Zone and if so, where is its western natural entrance point?

8. From West Bay to Pass Tante Phine. (U.S.C. & G.S. Chart No. 1272; Maps 7 and 8 of 8, La. Ex. 119 pp. 14–15.)

(a) What are the means of proof recognized by the Convention on the Territorial Sea and the Contiguous Zone for ascertaining whether particular elevations are above the level of mean low water?

(b) Does the Convention on the Territorial Sea and the Contiguous Zone control the kind of evidence that may be introduced in this case to identify low-water lines?

(c) Is Louisiana entitled to submerged lands measured from such low-tide elevations or low-water lines as shown on Chart No. 1272 between Pass du Bois and Pass Tante Phine but not shown on Maps 7 and 8 of 8, irrespective of evidence to the contrary?

(d) Where are there low-tide elevations or low-water lines in this area?

(e) Have there been changes in the coast line that would affect the future distribution of revenues heretofore accrued since June 5, 1950, and if so, when did the changes become effective?

9. From Sandy Point Bay to Scofield Bayou. (U.S.C. & G.S. Chart No. 1272; Maps 8 of 8 and 8 of 41, La. Ex. 119 pp. 15–16.)

(a) What are the means of proof recognized by the Convention on the Territorial Sea and the Contiguous Zone for ascertaining whether particular elevations are above the level of mean low water?

(b) Does the Convention on the Territorial Sea and the Contiguous Zone control the kind of evidence that may be introduced in this case to identify low-water lines?

(c) What is the mean low-water line, between 89°30′ W. and 89°32′ W.?

(d) Have there been changes in the coast line that would affect the future distribution of revenues heretofore accured since June 5, 1950 and, if so, when did the changes become effective?

10. Caminada-Barataria Bay complex. (U.S.C. & G.S. Chart No. 1273; Maps 10–12 of 41, La. Ex. 119 pp. 18–20)

(a) Should islands or low-tide elevations be regarded as forming separate mouths of a bay if one or more direct lines could be drawn between other natural entrance points of the bay so as to run wholly seaward of such islands or low-tide elevations

(c) Do Grand Isle and the Grand Terre Islands form such separate mouths of the Caminada-Barataria Bay complex?

(c) Where are the natural entrance points of the Caminada-Barataria Bay complex?

11. Caillou Bay. (U.S.C. & G.S. Chart No. 1275; Maps 19–22 of 41, La. Ex. 119 pp. 27–30.)

(a) Should the Isles Dernieres be considered part of the mainland?

(b) Is Caillou Bay a bay as defined by Article 7 of the Convention on the Territorial Sea and the Contiguous Zone?

(c) Is Caillou Bay a historic bay under principles of international law?

(d) Did actions of the United States prior to this suit have the legal effect of utilizing straight baselines to close Caillou Bay?

(e) Should islands or low-tide elevations be regarded as forming separate mouths of a bay if one or more direct lines could be drawn between other natural entrance points of the bay so as to run wholly landward of such islands or low-tide elevations?

(f) Do the Isles Dernieres form such separate mouths of a bay between the points x=2,157,920, y=135,521 and x=2,076,730, y=189,630?

(g) Where are the natural entrance points of Caillou Bay?

(h) If Caillou Bay is inland waters, how is the three-mile belt measured south of the Isles Dernieres?

(i) Have changes in geographical configurations divested Louisiana of title to any submerged lands in this area?

(j) Have changes in law divested Louisiana of title to any submerged lands in this area?

12. Atchafalaya Bay. (U.S.C. & G.S. Charts Nos. 1276 and 1277; Mays 25–26 of 41 and 1–5 of 5, La. Ex. 119 pp. 33–39.)

(a) Are there low-tide elevations west of Point au Fer that should be considered part of the mainland? (U.S.C. & G.S. Chart No. 1276; Map 1 of 5, La. Ex. 119 p. 34.)

(b) Should the Shell Keys south of Marsh Island be considered part of the mainland? (U.S.C. & G.S. Chart No. 1277; Map 4 of 5, La. Ex. 119 p. 37.)

(c) Where are the natural entrance points of Atchafalaya Bay?

(d) If the distance between the natural entrance points exceeds 24 miles, where should the closing line or lines be drawn?

B

For the purposes of the present cross motions for entry of a second supplemental decree as to the State of Louisiana, the parties agree to accept the set of 54 maps filed with the Special Master as correct representations of the present high- and low-water lines, with the following exceptions:

(a) The United States reserves the right to show that the spoil bank shown on Map 8 of 8 as extending westward from the northern headland of Pass Tante Phine has ceased to be above the level of mean low water;

(b) The United States reserves the right to show that the mean low-water line west of Sandy Point Bay between 89° 30′ W. and 89° 32′ W. differs from that shown on Map 8 of 41;

(c) Louisiana reserves the right to show that in the area from Pass Tante Phine running southerly to the vicinity of the mouth of Pass du Bois, in addition to the low-water lines reflected on Map 8 of 8, there are more seaward mean low-water lines marked on large scale charts officially recognized by the coastal state, which must be given effect in delimiting Louisiana's coast line;

(d) Louisiana reserves the right to show that in the area of East Bay, seaward of the mean low-water line reflected on Map 4 of 8, in addition to said mean low-water line there is an additional mean low-water line configuration which is marked on official large scale charts officially recognized by the United States, and which should be given full effect by the Master;

(e) Louisiana reserves the right to show that islands or low-tide elevations exist south of the mouth of South Pass that were not reflected on Map 4 of 8;

(f) It is agreed that they coordinate of the mudlump east of Pass a Loutre, shown on Map 2 of 8, La. Ex. 119 p. 9, as x=2,754,100, y=189,915, should be y=186,915.

This agreement to accept as correct the water lines shown on the set of 54 maps does not preclude the parties from introducing evidence, not inconsistent with those maps, of geological, physical, or other facts, including but not limited to water depths, inland portions of water lines left incomplete on the set of 54 maps, particularly inclusion of tributary waters in measurements for the semicircle test, and conditions that existed prior to the surveys on which the 54 maps were based. Also, the parties may show the history and usage of these areas. Neither will acceptance of the 54 maps for the purpose stated preclude the parties hereafter, on future motions for entry of further supplemental decrees to have only prospective effect, from showing changes from the conditions on the 54 maps. Neither does this agreement imply that the parties accept as correct the methods used in making the 54 maps.

C

With one exception, the parties agree that all issues should be presented to the Special Master for decision, even though his conclusions as to some may eliminate others. This will enable the Supreme Court to have the benefit of his views on every point that may become material to its disposition of the case.

The United States makes an exception with respect to the issue stated as question (c) under area 1 and as issue (j) under area 11—that is, whether changes in the law have divested Louisiana of title to any submerged lands in those areas. Specifically, this is intended to raise the question of whether the United States can diminish a State's submerged lands by entering into an international agreement that defines inland waters in such a way as to exclude areas formerly recognized as inland waters. The United States does not believe that this question arises on the facts of this case, because it does not believe that any waters not within the definition of inland waters under the Convention on the Territorial Sea and Contiguous Zone were previously recognized as inland waters. Whether a treaty could have the effect that Louisiana attributes to the Convention on the Territorial Sea and the Contiguous Zone is a constitutional question of great importance, which the Supreme Court has heretofore avoided considering. See *United States* v. *California*, 381 U.S. 139 at 168 (1965). Adequate consideration of the question would require an extended study of constitutional law and history. It is a general question of constitutional law, decision of which will not depend in any way on the peculiar facts or legal issues of this case. Accordingly, the United States sees no reason to suppose that the Supreme Court would find it necessary to remand the case to the Special Master for advice on this point, if he should have found it unnecessary to reach the question, and the Supreme Court should conclude otherwise. For these reasons, the United States urges that this question not be briefed or argued here unless the Special Master himself concludes that he cannot decide the case without reaching this question, in which event he should then call for supplemental briefing and argument by both parties on this point. Louisiana contends that the United States has recognized preserves or reserved areas as inland waters and that neither subsequent treaties nor subsequent abandonment of these areas can deprive Louisiana of these areas except as the same may extend beyond the limits set in Act 33 of 1954. Louisiana's position is that the treaty could not constitutionally divest Louisiana of property and if the Special Master finds the effect of this treaty purports to work such a divestiture, the constitutional question must be considered.

The parties suggest that one month before the opening of the trial, the parties shall furnish to the Special Master and to the other party a list of the documents they then intend to introduce and a list of the witnesses they then intend to call, with a brief description of each witness' qualifications, the facts to which he will testify, and the documents to which he will refer. With such list, the parties shall furnish copies of all unpublished documents listed, or of the parts thereof to be relied on. If, after expiration of the time for submitting such lists of witnesses and documents, unforeseen circumstances make it necessary for a party to present a witness or document not listed, the party, immediately upon becoming aware of such circumstances, shall furnish such information to the Special Master and to the other party. These requirements shall not apply to witnesses or documents used on rebuttal. The parties stipulate that copies of the documents may be introduced in lieu of originals, and that authenticity of documents and accuracy of copies need not be proved unless challenged within 20 days after receiving a copy or controverted by evidence at any time.

Respectfully,

ERWIN N. GRISWOLD,
Solicitor General of the United States.
JACK P. F. GREMILLION,
Attorney General of Louisiana.

December 1969.

STATEMENT SUBMITTED BY THE HONORABLE RONALD REAGAN, GOVERNOR, STATE OF CALIFORNIA

STATE OF CALIFORNIA,
GOVERNOR'S OFFICE,
Sacramento, Calif., May 12, 1972.

Hon. HENRY M. JACKSON,
Chairman, Committee on Interior and Insular Affairs, U.S. Senate, Washington, D.C.

DEAR SENATOR JACKSON: Thank you for your letter of April 14, 1972, and for the opportunity to comment on the various aspects of the Outer Continental Shelf petroleum operations.

This nation faces a very real and pressing energy crisis and California has a particularly acute energy problem in that we are a deficit state in regard to oil, gas, and hydroelectric power. Although the third ranking oil producer in the nation, California must still import approximately one-third of its petroleum and three-quarters of its natural gas. Some 95 percent of our total energy needs are met by oil and gas; therefore, policy concerning offshore production is of particular importance to us. Two aspects which we consider of utmost importance are:

1. That California should regulate Outer Continental Shelf petroleum operations. California has the staff, the expertise, and the ability to regulate all oil and gas operations off the California coast.

Starting in 1968, personnel from the Resources Agency have met with their federal counterparts to discuss this problem. In 1969, the State Senate passed a resolution memorializing the President and Congress to transfer regulatory authority to the State. I have made personal requests to the Vice President and the Secretary for the Resources Agency, Mr. Livermore, has discussed this proposal with the Secretary of the Interior. Our requests have been continually denied. California has an unparalleled record of safety and quality regulation in our offshore waters. Of the more than 4,000 wells and coreholes drilled, there have been no pollution incidents.

The Federal record is not as impressive. Blowouts and fires have occurred on platforms in the Gulf coast. The only blowout offshore from California was in federal waters.

2. California and other states with OCS oil production should share, to some degree, in the revenue from OCS operations. It is necessary for the adjoining counties to fill the needs of the producers in terms of law enforcement, fire protection, schooling, etc., but they are unable to assess ad valorem tax on the property or collect sales tax on goods sold to the offshore operators.

In answer to the specific questions raised by the Senate Committee, we are forwarding a statement detailing California's position under separate cover to Mr. William J. Van Ness, Chief Counsel to the Committee and Study Director of the National Fuels and Energy Study. We are also enclosing two reports: (1) A comprehensive publication entitled "The Offshore Petroleum Resource," which deals mainly with state-owned tibelands, and (2) the results of a fact-finding committee formed following the Santa Barbara Channel incident entitled "Report of the Ad Hoc Committee, State Regulations and Practices, Oil and Gas Operations and Oil Pollution."

Thank you again for the opportunity to comment on these vital questions. Your committee is to be commended for this investigaion.

Sincerely,

RONALD REAGAN, *Governor.*

Enclosures.

STATE OF CALIFORNIA—RESOURCES AGENCY

RONALD REAGAN, Governor

DEPARTMENT OF CONSERVATION

DIVISION OF FORESTRY
DIVISION OF MINES AND GEOLOGY
DIVISION OF OIL AND GAS
DIVISION OF SOIL CONSERVATION

SACRAMENTO, CALIFORNIA
1416 Ninth Street

Honorable Norman B. Livermore, Jr.
Secretary, Resources Agency
1416 Ninth Street
Sacramento, California 95814

Dear Mr. Livermore:

Transmitted herewith is "The Offshore Petroleum Resource," a report by the Department of Conservation in response to Cabinet Issue Memo R-70-14.

This report contains three sections. The first describes the resource as it is known at the present time. The second section details the development of the resource to date, the various agencies having regulatory responsibilities, and the "state of the art" of drilling and production technology. The third section discusses various impact areas in relation to the development of the resource.

This project was coordinated by the Division of Oil and Gas and includes major contributions by the State Lands Division and the Division of Mines and Geology. Other contributions were made by:

California Advisory Commission on Marine and Coastal Resources
Department of Commerce
Department of Conservation
Department of Finance
Department of Fish and Game
Department of Navigation and Ocean Development
Department of Parks and Recreation
Department of Water Resources
Environmental Quality Study Council
Office of Emergency Services
State Water Resources Control Board

Sincerely,

James G. Stearns
Director

THE OFFSHORE PETROLEUM RESOURCE ABSTRACT

Following the blowout at Platform A in the Santa Barbara Channel, in federal waters, national attention was focused on the problems of offshore petroleum development. The purpose of this paper is to fill a need for an official, factual report on the factors that affect the recovery of offshore oil. Some 85 percent of the nation's energy is supplied directly or indirectly by the fossil fuels, such as petroleum and natural gas. California is the third-ranked oil-producing state and about 30 percent of this production comes from fields on the continental shelf.

The continental shelf of California is a submerged portion of the continent and consists of an area of 35,000 square miles. It is 15-30 miles wide north of San Francisco, but fans out to more than 160 miles at the Mexican Border and includes the offshore islands. By a decision of the Supreme Court the portion of the shelf under state control extends three miles out from the coast. The State Lands Division estimates that the potential oil reserve for the continental shelf in waters up to 200 fathoms (1200 feet) in depth at nearly six billion barrels. The potential reserve for the entire Santa Barbara Channel, including both federal and state waters, has been estimated at four billion barrels. These potential reserves can be compared to an estimated *proved* reserve of 5.7 billion barrels for the state, both onshore and offshore.

To date the direct revenue to the state from royalty and bid bonuses is in excess of $786 million and if drilling and production were to continue on the existing 131 state leases the additional estimated income would be $258 million. It has been further estimated that if leasing were renewed that in excess of one billion dollars in revenue would be forthcoming. In the past this income has primarily benefited the water and education funds. If all state leases were terminated, there would be several sizable economic losses. One is the cost of litigation from the canceling of contracts; these costs cannot be accurately estimated. (The question of liability of the state, if any, is beyond the scope of this paper.) Second, there would be a loss of direct revenue to the counties from ad valorum taxes, which at present totals $17 million per year. Third, there would be a loss of salaries from employment which now totals about $40 million per year. Fourth, there would be a loss of benefits to the local communities derived from the cost of developing the properties.

As a result of the blowout, many law suits have been filed, some by private citizens, two by the State of California in conjunction with several cities and counties, one against the involved companies, and another against the U. S. Government.

Certain offshore petroleum sanctuaries have been established by the state and federal governments. State-owned lands presently excluded from leasing total 2,574,000 acres. Several bills before the state legislature propose to establish additional sanctuaries on state lands. A number of bills have also been introduced in the U. S. Senate and the House of Representatives to extend sanctuaries on federal lands.

California oil operators pioneered the discovery and development of offshore petroleum deposits and the technology of marine drilling and production. The first offshore drilling was from piers but as oil was found further from shore, drilling and production operations were extended to man-made islands, fixed drilling platforms, and floating drilling units. Work on subsea equipment, so that there is no need for permanent above-water installations, is progressing but has not as yet been completely developed. Industry in California has an enviable record of safe operation. From 1957 through 1968,

682 wells were drilled on state offshore leases under state regulation and jurisdiction; other wells were slant-drilled into offshore lands from upland drillsites. In addition, 708 offshore core holes were drilled under state regulation and supervision, 465 of which were on what is now designated federal OCS lands. *No significant oil spill resulted from the drilling of any of these wells.*

Several state agencies have jurisdiction, principally the Division of Oil and Gas,which has regulatory functions, and the State Lands Division, which represents the state as the landowner. The State of California has a comprehensive set of offshore regulations to ensure safety.

The problem of compatibility of offshore oil development and the purely esthetic value of the scenic coastline can never be completely resolved because esthetics have a different connotation to different people. As previously mentioned, the petroleum industry is attempting to develop underwater completion methods and has engaged in a beautification of their onshore facilities connected with offshore production.

Offshore petroleum development operations affect the ecology of the ocean. This effect may be either beneficial or harmful to marine life. Large fish populations have become established around platform installations. The real danger to the ecology from offshore oil operations or from petroleum tanker traffic is that of an oil well blowout or an oil spill. It has generally been found that the cleanup operations are more harmful to the animal life than is the oil spilled. Chemical methods used at the TORREY CANYON spill and the steam cleaning of the rocks at Santa Barbara are examples. The most readily ascertainable loss of wildlife directly attributable to the Santa Barbara oil spill was that of the aquatic birds; the estimated loss was 3,700. Not all marine biologists are in agreement on the ecological effects of an oil spill.

The ability to contain an oil spill on the water surface is dependent primarily on wind and sea conditions. At present there is no proven method of containing oil in the open sea although such an operation can be accomplished in protected harbor areas by utilizing booms and skimming equipment. Following the TORREY CANYON incident the President directed federal agencies to prepare for such an emergency and as a result the National Oil and Hazardous Substances Pollution Contingency Plan became operational in September 1968. In early 1969 the state replaced the then existing 1968 Marine Chemical Spill Disaster Control Plan with the present California Oil Spill Disaster Contingency Plan.

If offshore oil operations were terminated, the resultant increase in imports by oil tankers would vastly increase the chances of an oil spill. A study of spills which occurred throughout the world during the period 1956 through 1969 showed that fully 75 percent of all major spills originated from vessels, and approximately 70 percent of these occurred within one mile of shore. The three major spills that occurred off the California coast since February 1969, originated from tankers.

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SUMMARY

INTRODUCTION

Following the oil well blowout in federal waters in the Santa Barbara Channel on January 28, 1969, and the subsequent oil pollution, national attention focused on the inherent problems of offshore petroleum development. Furthermore, attention focused on the greater problem of the overall pollution of man's environment. Concern for a cleaner environment is not the exclusive domain of conservation groups but is shared by the State of California.

Some 85 percent of the nation's energy is supplied directly or indirectly by the fossil fuels such as petroleum and natural gas. California is the third-ranking oil producing state, and oil is the state's number one natural resource. About 30 percent of it comes from fields on the offshore continental shelf. Oil, like gold, is where you find it. Roughly half of California's oil reserves are found in the populous southern portion of the state.

In order for these petroleum resources to be effectively, efficiently and safely developed for the maximum benefit of the people of the state, more must be understood about the interplay of scientific, economic and social disciplines that relate to these operations.

The purpose of this paper is to fill the need for an official, factual report on the factors of ecology, economics, esthetics, petroleum technology, geology, legal implications, possible sources of pollution, the methods for containment, recovery and prevention of pollution, and the róles of the various regulatory agencies.

THE RESOURCE

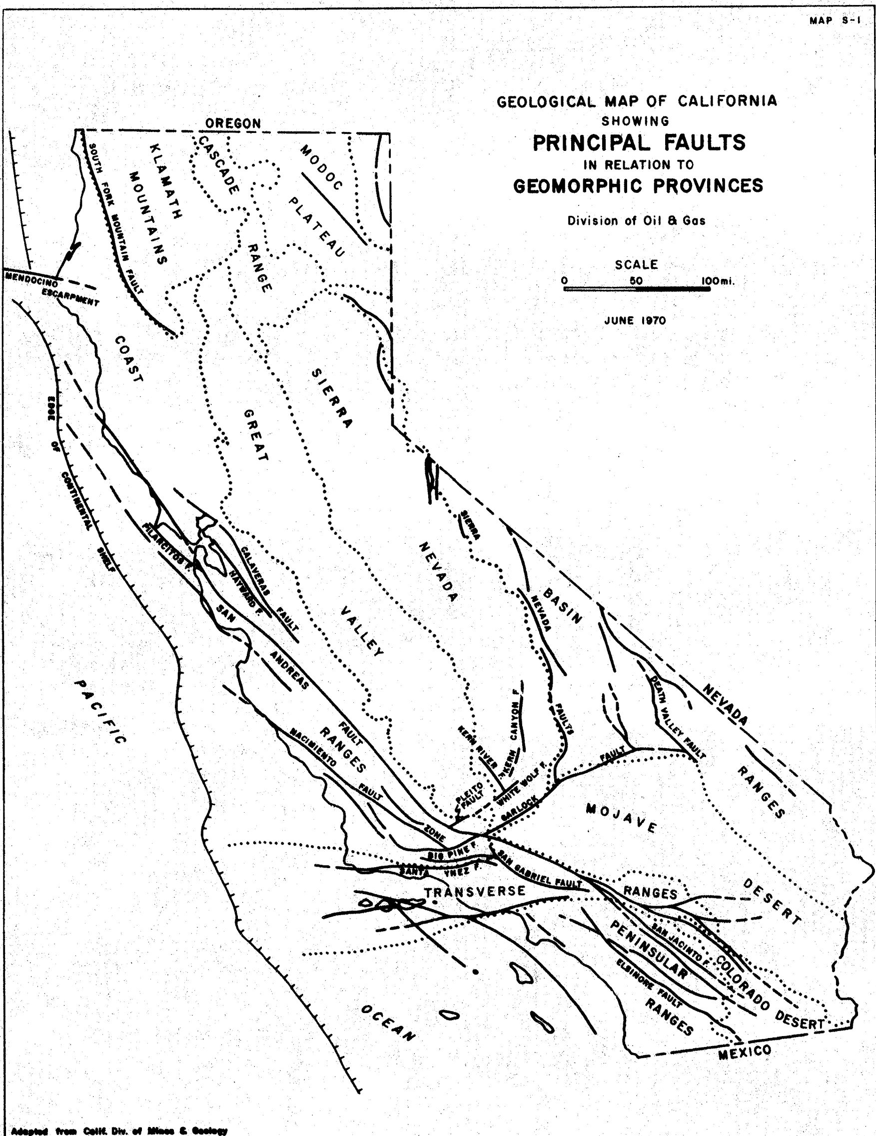
The continental shelf 1/ of California consists of an area of 35,000 square miles, about one-fifth the size of that of the land area of the state (Map S-1). North of San Francisco the shelf is 15 to 30 miles wide; but it fans out to the south and is more than 160 miles wide at the Mexican Border. The depth of the water varies out to the edge of the shelf, where the maximum ranges from 600 feet in the north to 5,000 feet in the south.

The Supreme Court of the United States in 1966 2/ explicitly delineated the area that the state may exploit for mineral extraction, and it can be approximately defined as the area between the coast of California or that of the offshore islands and a line three geographical (nautical) miles seaward; the total area is about 4,700 square (nautical) miles, or slightly over 13 percent of the shelf. Not all this area is owned by the state; portions have been granted to cities, therefore the distinction is here made between state-owned and state-regulated lands.

The continental shelf is topographically and geologically an extension of the adjoining coast. Relatively little sea floor geologic mapping has been done; however, the main structural trends have been projected, with the offshore islands serving as valuable tie-in points. Most of the geologic studies have been made in the Santa Barbara Channel area because of its economic importance. Additional statewide investigations by the Division of Oil and Gas, State Lands Division, and the Division of Mines and Geology are in progress.

1/ "Continental Shelf" is here defined as "the zone around the continent extending from the low water line to the depth at which there is marked increase of slope to greater depth".
Amer. Geol. Inst., 1962

2/ Appendix I-A


MAP S-1
GEOLOGICAL MAP OF CALIFORNIA
SHOWING
PRINCIPAL FAULTS
IN RELATION TO
GEOMORPHIC PROVINCES
Division of Oil & Gas
SCALE
0 50 100mi.
JUNE 1970
OREGON
KLAMATH MOUNTAINS
SOUTH FORK MOUNTAIN FAULT
CASCADE RANGE
MODOC PLATEAU
MENDOCINO ESCARPMENT
COAST
EDGE OF CONTINENTAL SHELF
GREAT VALLEY
SIERRA NEVADA
PILARCITOS F.
CALAVERAS FAULT
HAYWARD F.
SAN ANDREAS FAULT
RANGES
NACIMIENTO FAULT
PACIFIC
OCEAN
BASIN
NEVADA
SIERRA NEVADA
NEVADA
KERN CANYON F.
KERN RIVER
PLEITO FAULT
WHITE WOLF F.
GARLOCK FAULT
DEATH VALLEY FAULT
RANGES
MOJAVE
DESERT
ZONE
BIG PINE F.
SANTA YNEZ F.
SAN GABRIEL FAULT
TRANSVERSE
RANGES
PENINSULAR
SAN JACINTO F.
ELSINORE FAULT
RANGES
COLORADO DESERT
MEXICO
Adapted from Calif. Div. of Mines & Geology

Oil and gas are found in areas where sedimentary rocks have been deposited. An area of this type of deposition, in which the strata dip inward, is called a basin. There are nine major sedimentary basins along the California coast and each of these extends into the continental shelf. The two southernmost basins, Ventura-Santa Barbara and Los Angeles, are areas of major oil and gas development onshore and presently are the only ones with oil production offshore (Map S-2).

Of the 18 producing oil fields off the California coast, only one is wholly within federal waters. Another field overlaps the three-mile line and contains both federal and state leases. Seven of these fields also produce onshore. There are five productive dry gas fields, or zones, on the shelf and they are all in state waters (Map S-3, S-4 & Table S-1)

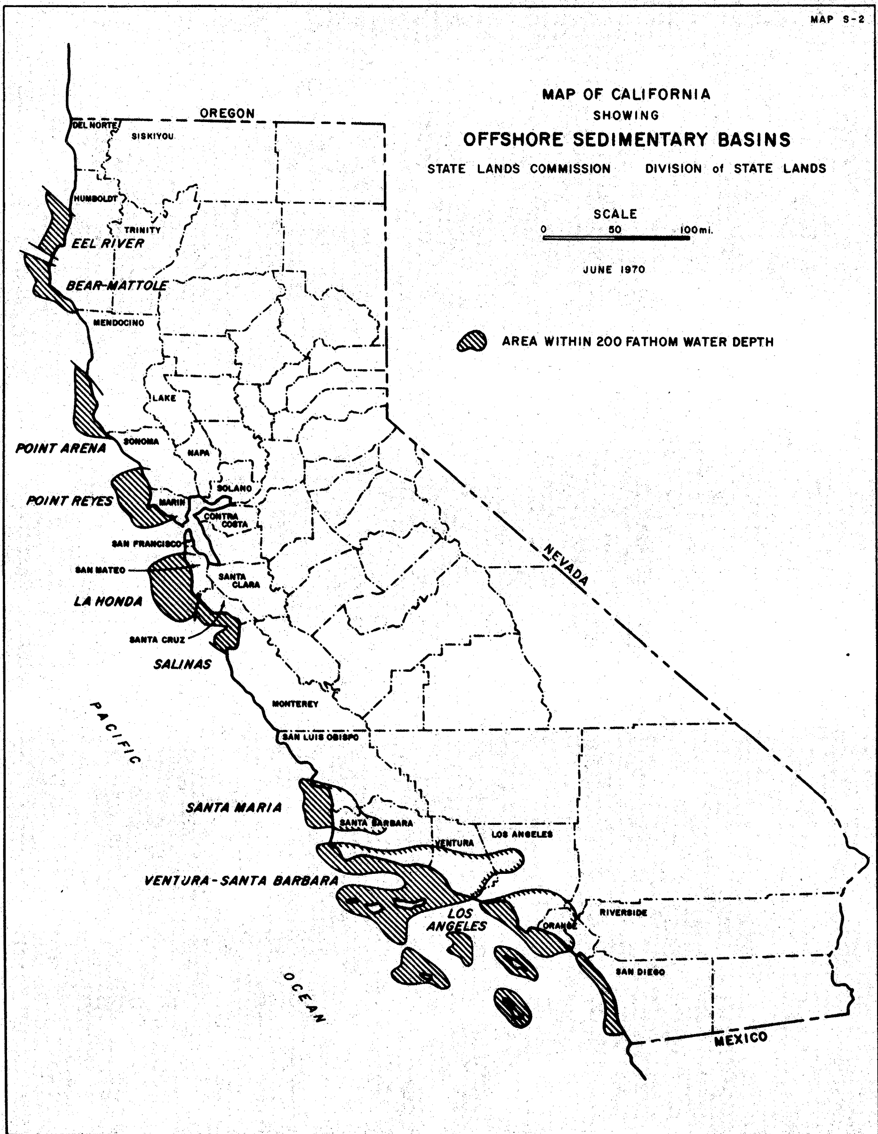
Through 1970, the cumulative offshore production was more than 1.21 billion barrels of oil and 1.07 billion Mcf. of gas; of these quantities, 1.18 billion barrels and 1.04 billion Mcf.[2/] were from state-controlled lands. During 1970, offshore production from state fields was about 79 million barrels of oil and 58 million Mcf. of gas (Table S-2).

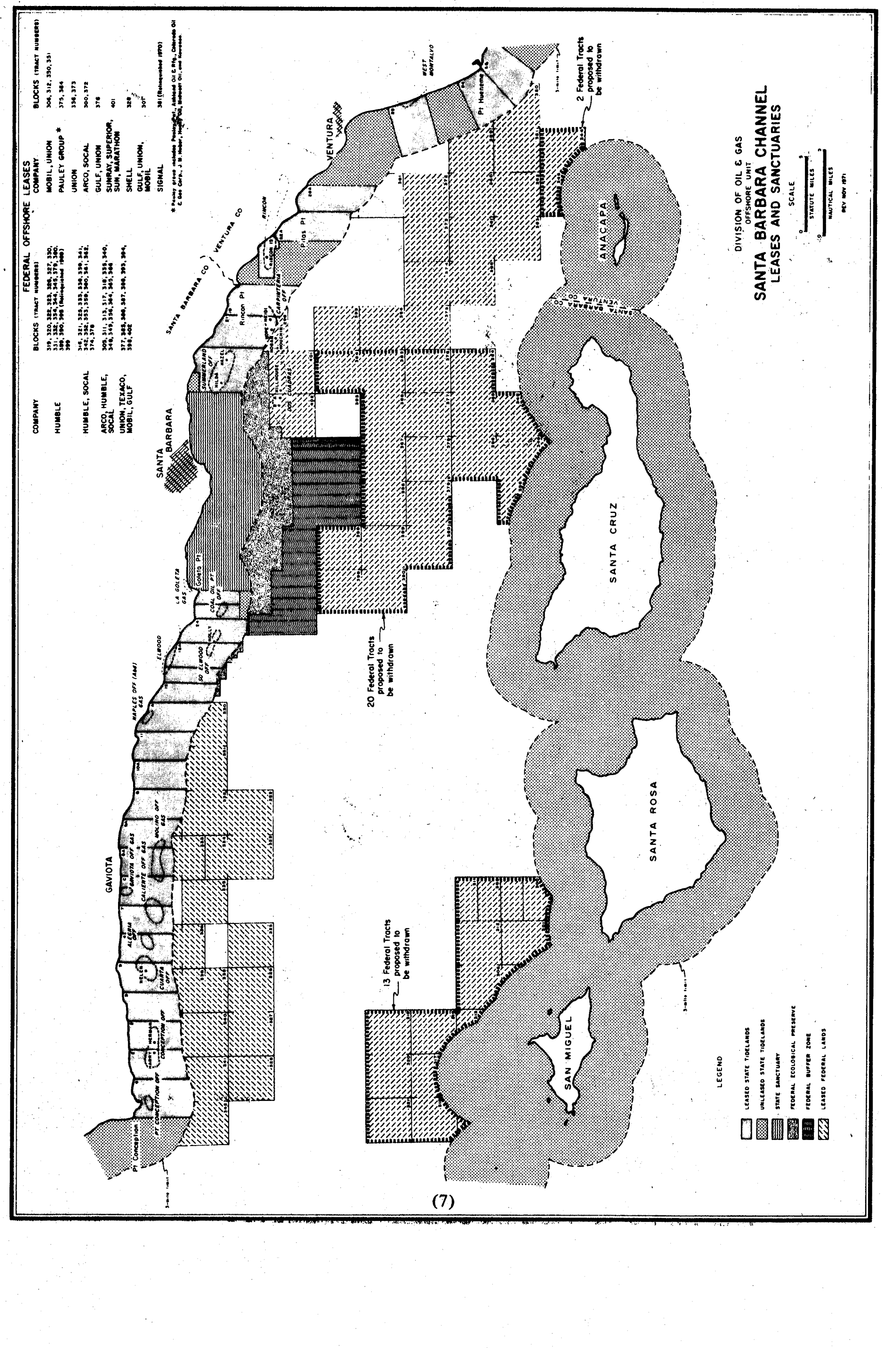
The estimated known or proved reserves, with current operating practices, for fields on state-controlled lands (including Wilmington field) are about 1.0 billion barrels of oil and 1.1 billion Mcf. of gas. In comparison, the estimated proved reserves for the entire state are 5.7 billion barrels of oil.

Two methods of stating oil reserves are as proved reserves or potential reserves; proved reserves are those known to exist and potential reserves are those presumed to exist.

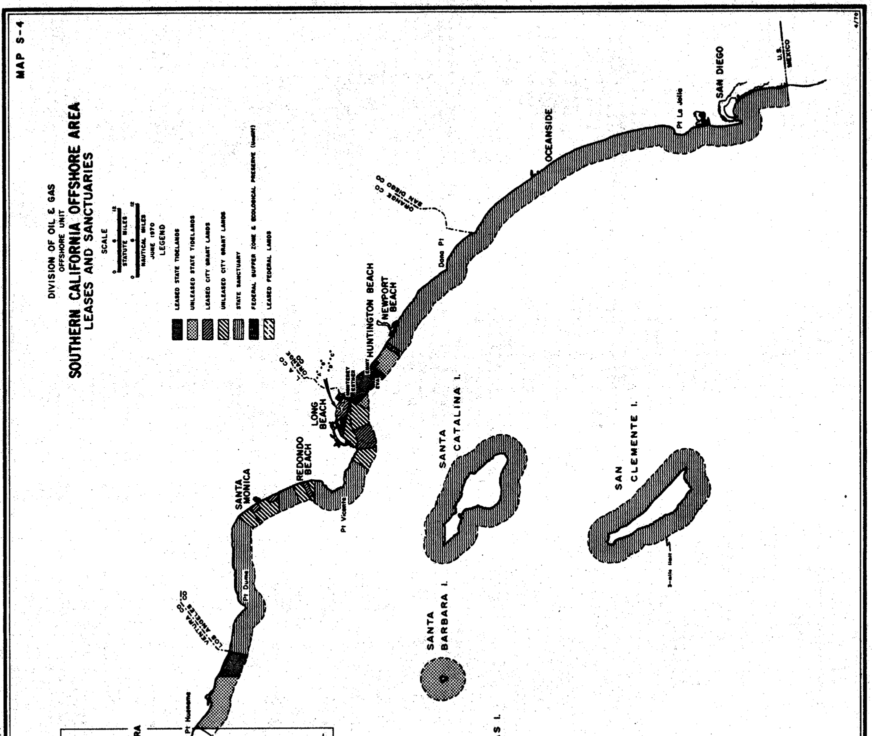
Before development began in federal waters, it was estimated that the potential oil reserves in the Santa Barbara Channel were 4.0 billion barrels. Subsequent development of Dos Cuadras and Carpinteria Offshore fields have made proved oil reserves about 250 million barrels. Recent discoveries by Humble Oil and Refining Company and Mobil Oil Corporation in the channel are reported to have possible reserves on the order of 1.0 billion barrels of oil. State Lands Division has estimated the potential oil reserves under all California coastal waters to the 200-fathom line to be nearly 6.0 billion barrels.

2/ Mcf. = thousand cubic feet


MAP S-2
MAP OF CALIFORNIA
SHOWING
OFFSHORE SEDIMENTARY BASINS
STATE LANDS COMMISSION DIVISION of STATE LANDS
SCALE
0 50 100mi.
JUNE 1970
AREA WITHIN 200 FATHOM WATER DEPTH
OREGON
DEL NORTE
SISKIYOU
HUMBOLDT
TRINITY
EEL RIVER
BEAR-MATTOLE
MENDOCINO
LAKE
POINT ARENA
SONOMA
NAPA
SOLANO
POINT REYES
MARIN
CONTRA COSTA
SAN FRANCISCO
SAN MATEO
SANTA CLARA
LA HONDA
SANTA CRUZ
SALINAS
NEVADA
PACIFIC
MONTEREY
SAN LUIS OBISPO
SANTA MARIA
SANTA BARBARA
VENTURA
LOS ANGELES
VENTURA-SANTA BARBARA
LOS ANGELES
RIVERSIDE
ORANGE
SAN DIEGO
OCEAN
MEXICO


FEDERAL OFFSHORE LEASES
COMPANY
BLOCKS (TRACT NUMBERS)
HUMBLE
HUMBLE, SOCAL
ARCO, HUMBLE, SOCAL
UNION, TEXACO, MOBIL, GULF
MOBIL, UNION
PAULEY GROUP *
UNION
ARCO, SOCAL
GULF, UNION
SUNRAY, SUPERIOR, SUN, MARATHON
SHELL
GULF, UNION, MOBIL
SIGNAL
DIVISION OF OIL & GAS
OFFSHORE UNIT
SANTA BARBARA CHANNEL
LEASES AND SANCTUARIES
SCALE
STATUTE MILES
NAUTICAL MILES
LEGEND
LEASED STATE TIDELANDS
UNLEASED STATE TIDELANDS
STATE SANCTUARY
FEDERAL ECOLOGICAL PRESERVE
FEDERAL BUFFER ZONE
LEASED FEDERAL LANDS
SANTA BARBARA CO
VENTURA CO
VENTURA
SANTA BARBARA
RINCON
Rincon Pt
Pitas Pt
Pt Hueneme
WEST MONTALVO
GAVIOTA
Pt Conception
PT CONCEPTION OFF
Goleta Pt
LA GOLETA GAS
ELWOOD
NAPLES OFF (AM) GAS
CARPINTERIA OFF
20 Federal Tracts proposed to be withdrawn
13 Federal Tracts proposed to be withdrawn
2 Federal Tracts proposed to be withdrawn
ANACAPA
SANTA CRUZ
SANTA ROSA
SAN MIGUEL
3-mile limit

(7)



MAP S-4
DIVISION OF OIL & GAS
OFFSHORE UNIT
SOUTHERN CALIFORNIA OFFSHORE AREA
LEASES AND SANCTUARIES
SCALE
STATUTE MILES
NAUTICAL MILES
JUNE 1970
LEGEND
LEASED STATE TIDELANDS
UNLEASED STATE TIDELANDS
LEASED CITY GRANT LANDS
UNLEASED CITY GRANT LANDS
STATE SANCTUARY
FEDERAL BUFFER ZONE & ECOLOGICAL PRESERVE
LEASED FEDERAL LANDS
DETAIL MAP
SANTA BARBARA CHANNEL
LEASES AND SANCTUARIES
Pt Arguello
Pt Concepcion
GAVIOTA
Goleta Pt
SANTA BARBARA
SANTA BARBARA CO
VENTURA CO
Rincon Pt
VENTURA
Pt Hueneme
SAN MIGUEL I.
SANTA ROSA I.
SANTA CRUZ I.
ANACAPA I.
VENTURA CO
LOS ANGELES CO
Pt Dume
SANTA MONICA
REDONDO BEACH
Pt Vicente
LONG BEACH
L A CO
ORANGE CO
HUNTINGTON BEACH
NEWPORT BEACH
Dana Pt
ORANGE CO
SAN DIEGO CO
OCEANSIDE
Pt La Jolla
SAN DIEGO
U.S.
MEXICO
SANTA CATALINA I.
SAN CLEMENTE I.
SANTA BARBARA I.
SAN NICOLAS I.

TABLE S-1

CALIFORNIA OFFSHORE OIL AND GAS FIELDS

Oil Field and County	Year of Discovery	Peak Production and Year (bbl. or Mcf.)	Geologic and Reservoir Data: Producing Zone and/or Formation	Age	Thickness (feet)	Avg. Depth (feet)	Type of Trap	Gravity or B.t.u.	Proved Acreage	Deepest Well Data: Depth (feet)	Formation and/or Age	Drillsite and/or Completion Facilities
Alegria Offshore (Santa Barbara)	1962	77,033 (1970)	Vaqueros Alegria	L Miocene Oligocene	110 180	3,800 3,900	Faulted anticline	38°	20	6,010	Alegria/Oligocene	Floating barge/sea floor
Belmont Offshore (Orange)							Faulted anticline		720	11,695	---	Islands Esther and Monterey
Old Area	1948	1,504,098 (1961)	Upper/Repetto Lower/Puente	L Pliocene U Miocene	160 200	3,100 5,900		19-22°	335			
Surfside Area	1965	3,615,984 (1968)	A.& B/Repetto C,D,E,F,G,H/Puente	L Pliocene U Miocene	170 795	3,000- 6,000		30°	385			
Carpinteria Offshore (Santa Barbara) (Fed.-OCS Tract 298)	1966	10,435,543 (1969)	F/Repetto G/Repetto Upper H/Repetto Lower H/Repetto J/Repetto K/Repetto O/Repetto	L Pliocene L Pliocene L Pliocene L Pliocene L Pliocene L Pliocene L Pliocene	100 150 200 200 250 50 50	2,100 2,800 3,300 3,500 4,200 4,600 6,000	Faulted anticline	19-31°	1,000	14,552	Miocene	Platforms Heidi & Hope (State); Hogan & Houchin (Fed.)
Coal Oil Point Offshore (Santa Barbara)	1961	232,136 (1966)	Vaqueros Sespe	L Miocene Oligocene	50 350	5,450 5,600	Anticline	29-30°	20	6,818	---	Floating barge/sea floor
Conception Offshore (Santa Barbara)	1959**	5,001,722 (1964)	Vaqueros Alegria Gaviota	L Miocene Oligocene Oligocene	30 250 100	4,600 3,000 4,400	Anticline	32-42°	450	7,828	Oligocene	Platforms Harry & Herman/ sea floor; onshore
Cuarta Offshore (Santa Barbara)	1959	84,694 (1963)	Alegria Gaviota Sacate Cosy Dell	Oligocene Oligocene U Eocene U Eocene	150 250 150 150	4,150 5,400 6,400 6,800	Anticline	28-36°	120	7,447	---	Platform Helen
Dos Cuadras Offshore (Fed.-OCS Tract 402)	1968	19,835,134 (1970)	Red/Repetto Brown/Repetto Upper 402/Repetto Lower 402/Repetto	Pliocene Pliocene Pliocene Pliocene	100 530 700 500	200 400 850 2,350	Faulted closed anticline with thrust fault parallel to axis	19° 23° 27° 35°	1,800	13,508	---	Platforms A, B & Hillhouse (Fed.)
Elwood, offshore area	1929	7,788,082 (1931)	Rincon Vaqueros Upper Sespe Bell 14/Sespe Lower Sespe	Miocene Miocene Oligocene Oligocene Oligocene	1,000 320 100 60 250	2,600 3,400 3,700 4,500 5,620	Anticline	26° 38° 36° 42° 34°	225	9,996	Eocene (?)	Onshore
Elwood, South, Offshore (Santa Barbara)	1965	1,929,085 (1968)	Sisquoc Monterey Rincon sand/Rincon Vaqueros Sespe	Pliocene Miocene L Miocene L Miocene Oligocene	10 500 150 60 150	1,350 3,350 5,000 5,900 6,000	Faulted anticline	25-34°	95	8,320	Oligocene	Platform Holly
Huntington Beach, offshore area (Orange)	1930	13,796,202 (1955)	U Jones/Puente L Jones/Puente Main/Puente	U Miocene U Miocene U Miocene	200 200 450	2,400 2,700 3,800	Faulted anticline	18° 19° 22°	2,345	13,516	Puente/U Miocene	Platforms Emmy & Eva; onshore
Montalvo, West, offshore area (Ventura)	1953	608,693 (1958)	Colonia/Sespe	Oligocene	2,500*	11,500	Faulted stratigraphic trap	12-19°	280	13,939	Sespe/Oligocene	Onshore
Newport, West, offshore area (Orange)	1953	352,539 (1957)	Newport/Puente	U Miocene	470	3,750	Faulted anticline	19°	80	10,886	Miocene	Onshore
Point Conception Offshore	1965	153,617 (1970)	Sacate	Eocene	500	2,800	Anticline	32°	40	8,780	Eocene	Onshore
Rincon, offshore area (Ventura)	1930	1,271,457 (1960)	Top & Intermed., & Miley	Pliocene	800	2,100	Faulted anticline	25-30°	550	7,725	Repetto/Pliocene	Rincon Island, piers, sea floor, onshore
Summerland Offshore (Santa Barbara)	1958	3,792,551 (1964)	Vaqueros	L Miocene	250-500	6,500	Faulted anticline	29-60°	685	8,454	---	Platforms Hazel & Hilda
Torrance, offshore area (Los Angeles)	1956	857,170 (1958)	Main/Puente Del Amo/Puente	U Miocene U Miocene	20 40	2,400 2,800	Faulted anticline	14-28° 26-30°	390	7,616	U Miocene	Onshore
Venice Beach offshore (Los Angeles)	1966	544,354 (1968)	Schist conglomerate/Puente	U Miocene	100	6,000	Anticline over basement high	22°	80	9,082	Schist/Jurassic	Onshore
Wilmington, offshore area (Los Angeles)	1939	64,775,754 (1969)	Tar/Repetto Ranger/Repetto & Puente U Terminal/Puente L Terminal/Puente U.P./Puente Ford/Puente 237th/Puente Schist	L Pliocene L Pliocene-U Miocene U Miocene U Miocene U Miocene U Miocene U Miocene Jurassic	120 150 300 360 125 300 200 15	2,200 2,500 3,000 3,500 4,000 4,550 5,550 5,850	Faulted anticline	12-30°	7,344	9,892	Schist/Jurassic	Islands Grissom, White, Chaffee, Freeman; filled land
Dry Gas Fields and Zones												
Belmont Offshore - Gas Zone (Orange)	1962	1,133,308 (1967)	Tar/Repetto	L Pliocene	30	2,850	Faulted anticline	1,100	***40	---	---	Island Esther
Caliente Offshore Gas (Santa Barbara)	1962	4,284,901 (1967)	Vaqueros	L Miocene	200	6,000	Faulted asymetrical anticline	1,160	140	7,912	Alegria/Oligocene	Floating barge/sea floor
Cuarta Offshore - Gas Zone (Santa Barbara)	1959	3,274,299 (1963)	Vaqueros	L Miocene	50	4,200	Anticline	1,090	***120	---	---	Platform Helen
Gaviota Offshore Gas (Santa Barbara)	1960	8,994,473 (1964)	Vaqueros	L Miocene	500	6,000	Anticline	1,200	140	10,380	---	Onshore
Molino Offshore Gas (Santa Barbara)	1962	30,576,437 (1967)	Vaqueros Sespe	L Miocene Oligocene	140 250	6,200 6,400	Faulted anticline	1,050-1,150	620	8,541	Alegria/Oligocene	Floating barge/sea floor

* Composed of numerous thin, discontinuous sand lenses
** Not produced until 1961
*** Overlapping acreage

TABLE S-2

RESUME OF PRODUCTION - CALIFORNIA OFFSHORE FIELDS - 1970

Oil field or area	Average number producing wells Actual	Actual & Potential	Oil (bbl.)	Water (bbl.)	Gas (Mcf.)	Cumulative production Oil (bbl.)	Gas (Mcf.)
Alegria, offshore	1	1	77,033	4,764	182,246	231,292	2,679,739
Belmont Offshore	85	105	3,474,568	1,388,759	1,379,193	29,494,717	28,673,152
Carpinteria Offshore							
State waters	60	66	2,492,765	2,107,486	1,454,912	13,859,819	9,282,094
Federal waters	56	61	5,153,284	2,466,343	4,560,809	14,145,459	10,382,624
Coal Oil Point Offshore	3	3	64,919	151,185	139,600	1,141,643	2,835,933
Conception Offshore	22	45	400,579	2,639,572	352,380	20,424,471	11,879,751
Cuarta Offshore	3	9	11,269	210,309	39,861	611,400	6,747,551
Dos Cuadras Offshore							
Federal waters	94	100	19,835,134	1,043,726	9,326,916	22,999,352	10,593,991
Elwood, offshore area	14	49	129,194	1,227,663	561,983	76,166,430	64,299,949
Elwood, South, Offshore	11	13	921,476	154,272	1,056,479	4,914,386	6,333,151
Huntington Beach, offshore area	516	620	11,746,768	32,594,693	3,969,169	373,049,877	104,870,741
Montalvo, West, offshore area	7	11	112,327	97,380	0	4,834,837	3,242,743
Newport, West, offshore area *	14	16	119,566	141,968	41,195	3,421,399	1,120,908
Point Conception (all offshore)	3	3	153,617	193,727	59,478	153,617	59,478
Rincon, offshore area	70	114	567,091	544,348	461,425	26,996,039	29,687,107
Summerland Offshore	27	46	901,731	557,907	4,212,233	22,746,440	75,381,228
Torrance, offshore area *	24	30	95,833	429,037	121,459	3,908,748	3,088,755
Venice Beach, offshore area *	5	6	266,182	1,519,579	118,799	1,424,096	914,284
Wilmington, offshore area *	1,000	1,396	57,692,967	135,970,809	18,947,975	598,088,642	374,412,493
Totals	2,015	2,694	104,216,303	183,443,527	46,986,112	1,218,612,664	746,485,672
Dry gas field or zone							
Belmont Offshore - Gas Zone	1	2		0	76,920		3,645,417
Caliente Offshore Gas	2	3		18,137	2,793,980		25,370,660
Cuarta Offshore - Gas Zone	2	2		0	204,868		11,851,311
Gaviota Offshore Gas	3	3		67,408	3,773,377		66,320,768
Molino Offshore Gas	8	10		21,502	18,944,670		183,174,018
Totals	16	20		107,047	25,793,815		290,362,174

*Granted lands

REGULATION

There are three levels of government, federal, state, and local, which regulate offshore oil and gas operations. In state waters the principal agencies and their generalized duties are:

Division of Oil and Gas	Supervision of oil and gas drilling and producing operations
State Lands Division	Specific land-management responsibilities of leasing and developing state-owned lands
Department of Fish and Game	Protection of marine life
Water Resources Control Board	Protecting and enhancing the quality of waters of the state
Division of Industrial Safety	Workers safety through inspection of operations and of construction work

SANTA BARBARA OIL WELL BLOWOUT

On February 6, 1968, at a lease sale in Los Angeles, the Federal Government accepted the highest bids for oil leases on 71 tracts in the Santa Barbara Channel from 20 companies, acting alone or in partnerships. An oil discovery was made the following month on Tract 402, a parcel leased by a group consisting of Union Oil Company of California, Gulf Oil Corporation, Mobil Oil Corporation, and Texaco Inc., with Union Oil Company of California acting as the operator. The field was named Dos Cuadras. In September 1968, Platform A was set into position about five and one-half statute miles off the coast in 188 feet of water. The platform, designed to accommodate 54 producing wells, was equipped with both a conventional and a tilted drilling rig.

Development drilling from the platform, which began in November 1968, was stopped when the fifth well, No. 402-A-21, blew out on January 28, 1969. The well, which had been approved by the U. S. Geologic Survey District Engineer, was at a total depth of 3,479 feet and the drill pipe was being removed from the hole so that an electric log could be run, when gas began blowing at the surface through the drill pipe. The crew took various steps to shut in the well; finally they were forced to drop the drill pipe down the hole and the well was successfully contained by closing the rams on the blowout preventers. Pressure from the lower zone (top at approximately 3,000 feet) overpressured the shallower Brown zone (top at approximately 400 feet) and the successful containment was short-lived, as there was insufficient overburden above the bottom of the surface casing to contain the pressure from the lower zone within the well bore. Oil and gas erupted from the sea floor to the surface of the ocean. During the ten days of uncontrolled oil flow from the ocean floor the flow rate was variously estimated to be between 500 and 16,000 barrels per day. Further operations were undertaken in the well to cement off the lower zone and thus retain the pressure within the zone. After ten days, this was successful. Oil still seeps from the shallow zones through fractures to the ocean floor although most of it is being captured by submarine tents.

At first, following the blowout, containment and removal or dispersal of this oil was attempted by various methods. Chemical means were tried for only a few days and were unsuccessful. Several types of booms were constructed but none held together in the heavy seas; several skimming methods were attempted but were ineffective, and after that, efforts were limited to the application of straw and its subsequent removal from harbors and the shore. A general cleanup of the beaches, harbors and boats was undertaken voluntarily by the operator as soon as the well was generally contained. Operations included blowing of straw on the oily water and subsequently collecting the oil-soaked straw mulch, steam cleaning and sandblasting rocks and breakwaters, removal of oil-soaked sand, and cleaning or repainting of boats. Beach operations were retarded by the vast amount of debris, estimated at more than 30,000 tons, which was deposited by a large storm that just preceded the blowout. The oil-soaked material was disposed at dump sites in Ventura County, as the City of Santa Barbara refused use of its dump and the Santa Barbara County dump was closed by storm damage. Cleanup operations were performed by Conservation Camp inmates, supervised by Department of Conservation and Department of Corrections personnel, and contract labor. To date the operator reports it has expended nearly $5 million for cleanup.

NATURAL SEEPS

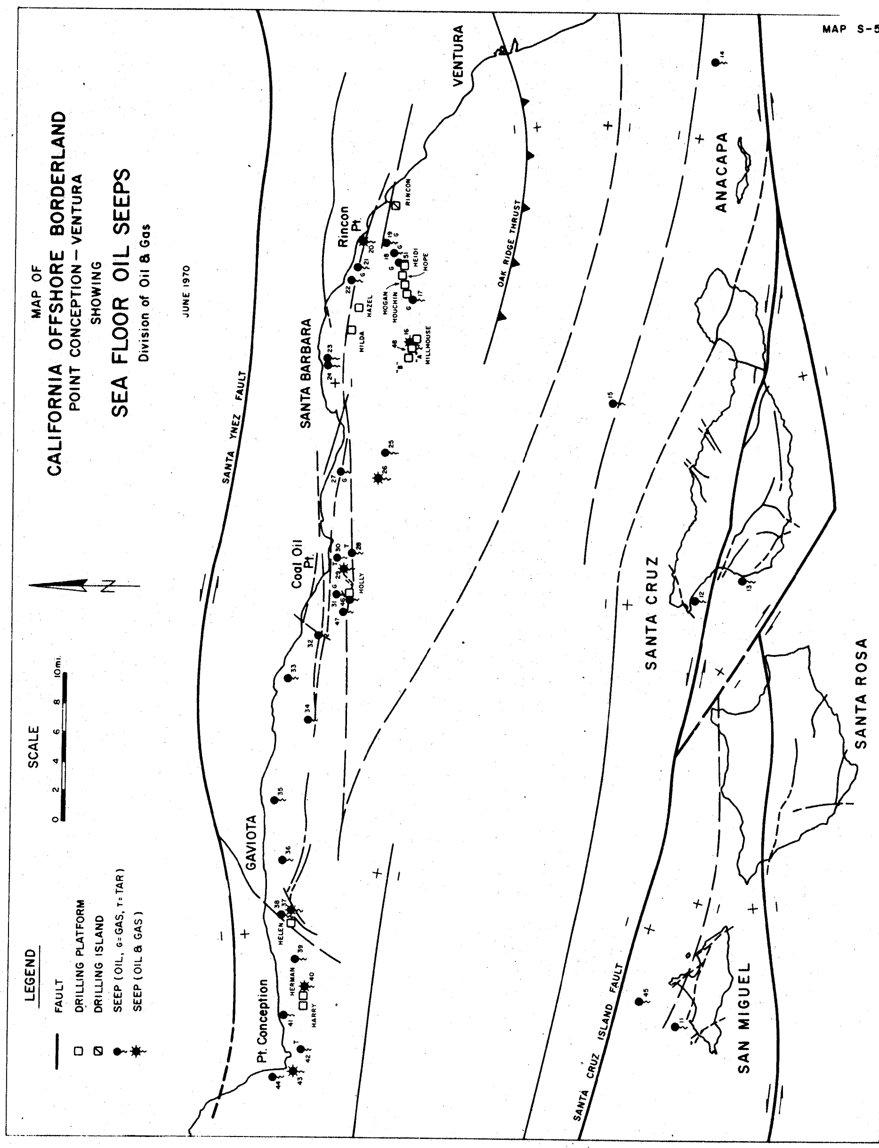
Oil and tar patches on the beach were a common complaint of coastal residents for many years prior to the Santa Barbara oil well blowout. Usually, oil operations were blamed, but most of the oil came from the numerous natural seeps that occur on the ocean floor or along the coast. The earliest mention of an offshore oil seep was by Father Pedro Font who wrote of his travels near Santa Barbara in 1776,. . ."much tar which the sea throws up is found on the shores, sticking to the stones and dry. Little balls of fresh tar are also found. Perhaps there are springs of it which flow out into the sea. . . ." The occurrence of seeps is an established but still not widely known fact. All areas of the world that have petroleum leak oil, that is, have seeps. Thus, the presence of seeps is of considerable interest to industrial geologists evaluating the economic potential of any offshore area. As a consequence, seeps are sought out and the actual seepage from the ocean floor observed wherever possible.

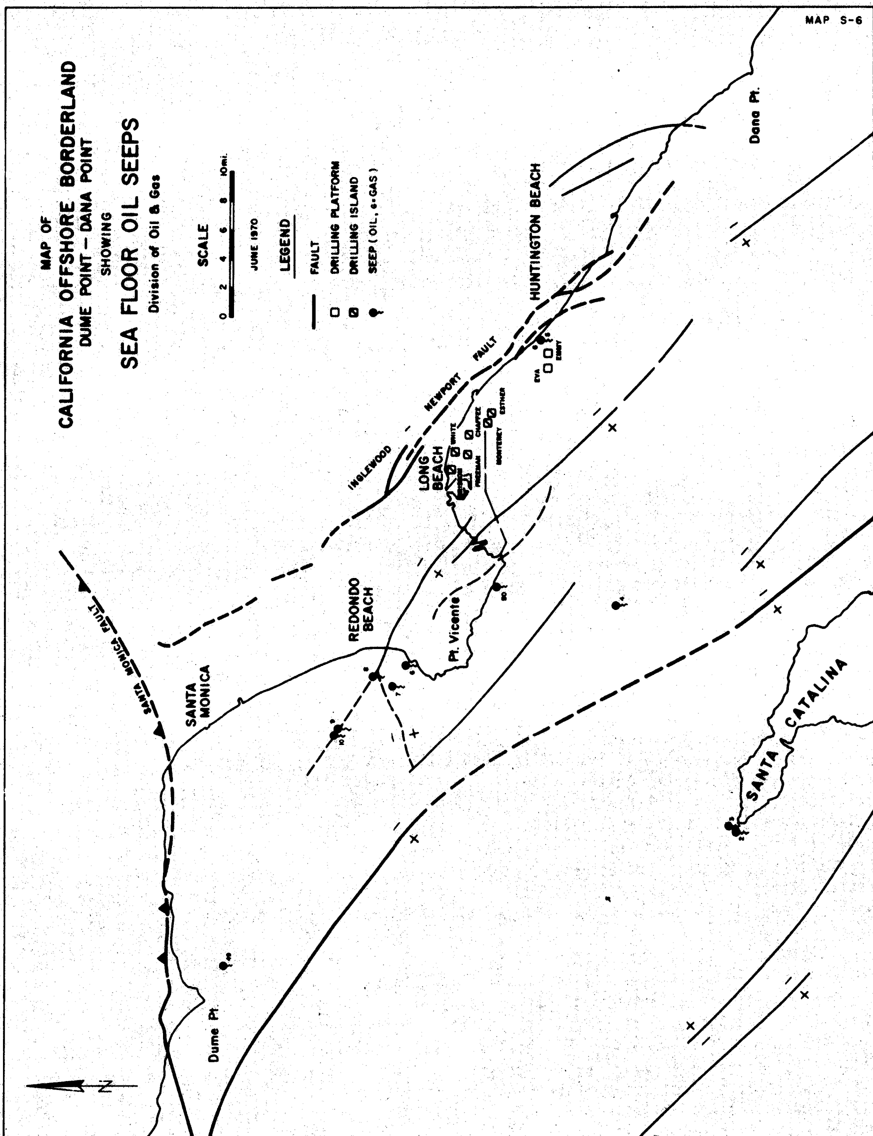
Most seeps are easily seen as oil slicks or gas bubbles on the surface of the sea. Some remain dormant for extended periods of time and then become reactivated, probably by pressure buildup or earth movement. Because of the transient nature of many seeps, an accurate count is difficult to obtain; however, it appears that there are probably 50 to 60 seeps and seep areas on the ocean floor between Point Conception in Santa Barbara County and Huntington Beach in Orange County. The accompanying Maps S-5 and S-6 show the oil, gas and tar seeps that have been documented by the Division of Oil and Gas.

ECONOMIC IMPACT

The value of California's petroleum exceeded one billion dollars in 1970; of this amount $240 million was from state-controlled tide and submerged lands. Over three billion dollars worth of oil has been recovered from these lands to date. About 172,000 people are employed by the petroleum industry in California with an annual payroll of more than $1.39 billion. About 5,000 people are involved in offshore operations.

The alternatives for the state relative to development of offshore oil reserves are fourfold: terminate all leases, no further leasing or drilling, no further leasing but continued drilling, continue leasing and drilling.


MAP S-5
MAP OF
CALIFORNIA OFFSHORE BORDERLAND
POINT CONCEPTION – VENTURA
SHOWING
SEA FLOOR OIL SEEPS
Division of Oil & Gas
JUNE 1970
SCALE
0 2 4 6 8 10mi.
LEGEND
FAULT
DRILLING PLATFORM
DRILLING ISLAND
SEEP (OIL, G=GAS, T=TAR)
SEEP (OIL & GAS)
VENTURA
Rincon Pt.
RINCON
HEIDI
HOPE
HOUCHIN
HOGAN
HAZEL
HILDA
HILLHOUSE
SANTA BARBARA
SANTA YNEZ FAULT
OAK RIDGE THRUST
Coal Oil Pt.
HOLLY
GAVIOTA
HELEN
HERMAN
HARRY
Pt. Conception
ANACAPA
SANTA CRUZ
SANTA ROSA
SAN MIGUEL
SANTA CRUZ ISLAND FAULT


MAP S-6
MAP OF
CALIFORNIA OFFSHORE BORDERLAND
DUME POINT – DANA POINT
SHOWING
SEA FLOOR OIL SEEPS
Division of Oil & Gas
SCALE
0 2 4 6 8 10mi.
JUNE 1970
LEGEND
FAULT
DRILLING PLATFORM
DRILLING ISLAND
SEEP (OIL, e-GAS)
HUNTINGTON BEACH
NEWPORT FAULT
INGLEWOOD
LONG BEACH
EVA
EMMY
ESTHER
REDONDO BEACH
Pt. Vicente
SANTA MONICA
SANTA MONICA FAULT
Dume Pt.
Dana Pt.
SANTA CATALINA

Direct revenue to the state from royalties and bid bonuses is in excess of $786 million (Table S-3); and if drilling and production were to continue as before on the existing 131 state leases (excluding Long Beach), the future income would be $258 million. This income has mainly benefited the water and education funds (Table S-4).

If the drilling moratorium established by the State Lands Commission on state-owned lands were to continue, it could result in an estimated revenue loss of $22.4 million through the 1972-73 fiscal year including an estimated $11.2 million which has already been lost. As the restrictions do not extend to the Long Beach operations (granted lands), those revenues would not be affected.

If all leases on state-owned tide and submerged lands were to be terminated, that is, production stopped, wells abandoned and leases bought back, the losses to the state would be multifaceted. First, there would be the loss of future income from existing leases, $258 million; second, possible return of the cash bonuses for the leases; and third, the costs of litigation, including resolution of development costs. The question of liability of the state, if any, is beyond the scope of this paper. No firm value has been set on the existing leases; but as an order of magnitude it is probably something less than one billion dollars.

In the immediately affected coastal areas of Orange, Los Angeles, Ventura, and Santa Barbara counties, ad valorem direct tax revenues for 1970-71 from tidelands oil fields were about $16,618,000, based on an assessed valuation of $153,058,000. Cessation of offshore oil and gas activities would virtually eliminate these revenues. Furthermore, there would be no possibility of augmenting the revenue by the discovery of new producing properties.

Federal lease values were cited in testimony on Senate Bill 1219 of the 91st Congress. Sale of 72 leases resulted in bonus payments totaling $623,908,262 to the Federal Government. Exploration and development costs, plus future earnings from discoveries, greatly increase the total investment in these federal leases.

Revenue to the Federal Government from these offshore leases was $5.5 million through 1969. A complete moratorium on future federal drilling would result in losses of revenue that would require other tax sources plus reimbursement of leasing and development costs.

During 1968-69, salaries from oil and gas employment totaled $256 million in eight coastal counties. If complete moratoriums were placed on drilling and production on both federal and state lands, the salary loss might be as much as $40 million per year. It is difficult to assess this figure accurately, because among other factors, some of the employment slack might be taken up by an increase in petroleum exploration and development in onshore fields.

California is dependent on outside sources of crude petroleum and refined products to the extent of 34 percent of its total needs, or approximately 530 thousand barrels per day, most of which is from foreign countries. The state imports 73 percent of its natural gas, principally by pipeline from Canada, the Four Corners area, and Texas. About 28 percent of California's oil production and 11 percent of the gas production emanates from offshore leases, both federal and state. Curtailment of offshore production would subject California to even greater dependence on foreign oil, the cost of which might not be static. Imported crude oil currently costs less than domestic, so curtailment would result in a depression of the price of domestic crude, in order to be competitive, along with reduced oil income and lower tax revenues. Additionally, increased imports would add greatly to the danger of tanker spills. This subject is discussed more fully under sources of pollution.

TABLE S-3
OIL AND GAS REVENUES
1955-56 THROUGH 1970-71

Source	Amount
Oil and Gas Royalties (State Leases)	$ 240,616,739
Bid Bonuses (State Leases)	189,910,958
Subtotal	$430,527,697
State Share of Long Beach Oil and Gas Revenues	346,332,000
Tract 2 of Long Beach Unit	9,430,682
Subtotal	$ 355,762,682
Grand Total	$ 786,290,379

TABLE S-4
DISTRIBUTION OF OIL AND GAS REVENUES
1955-56 THROUGH 1970-71

Purpose	
General Fund	$130,634,308
State Water Fund (including Central Valley Water Project Fund)	408,337,072
Education	
Local School Districts 1963-67	101,588,615
Capital Outlay for Public Higher Education 1967-71	75,634,066
Beach and Park Fund 1955-61	52,566,999
	$768,761,060

77-463 O - 72 - pt. 3 - 8

Measurement of the impact of an oil spill on the economy of an area is exceedingly complex, as many interrelated and some extraneous factors are involved. As a result of the Santa Barbara incident, the Chamber of Commerce of the City of Santa Barbara estimated that income generated from tourism was reduced by $930,000; the City of Carpinteria, $300,000. Other coastal communities not affected by the spill, showed increases of seven to ten percent for the 1969 summer period. Revenues from state beaches were reduced by an estimated 15 percent or $27,000. Specifically, the three state beaches in Ventura County had a reduction in attendance varying from 16 to 40 percent. Various other governmental entities and individuals have made claims as to losses incurred.

It must be noted that during the cleanup operations some 2,000 men, including Conservation Camp inmates, were utilized. Equipment such as front-end loaders, dump trucks, tractors and numerous small boats were used. Union Oil Company of California has claimed expenditures of nearly $5 million, most of it spent locally, for this cleanup work.

LEGAL ACTIONS

The blowout of Union Oil Company's well No. 402-A-21 in the Santa Barbara Channel has given rise to a host of private and public lawsuits and legal questions. The State of California, in conjunction with several cities and counties, is plaintiff in two damage actions, one against the involved companies and one against the United States. Several classes of private citizens, e.g., property owners, boat owners, fishermen, ships chandlers, and businessmen, have also filed suit for damages resulting from the blowout and resulting seepage. In addition, there are several suits asking for injunctions against offshore oil development and production. The state has supported one of these actions by acting as *amicus curiae,* which action would have compelled the Corps of Engineers, U. S. Army, to hold hearings regarding environmental factors in placement of drilling rigs as the Corps' regulations then required. The state also acts as counsel for the District Attorney of Santa Barbara County, who has been prohibited from bringing any criminal prosecutions for creating a public nuisance resulting from offshore oil activities against four named oil companies or their suppliers. These matters and applicable statutes, jurisdiction of state and federal agencies and regulations are discussed more fully in other sections.

The Federal Government is presently permitting drilling operations on its leases, some of which are adjacent to state lands. The Secretary of the Interior has suspended operations on 35 leases pending Congressional legislation to cancel those leases and create a national energy reserve adjoining the state's Santa Barbara sanctuary. The Secretary has also denied permits for an additional drilling and production platform on each of Union's and Sun's oil leases. As a result of continual drilling on federal leases, oil is possibly being drained from state leases and some leaseholders are incurring revenue losses due to the state moratorium. At least one has indicated that legal action may be taken against the state to recoup these alleged losses.

SANCTUARIES

Certain petroleum sanctuaries have been established by the state and federal governments. State-owned lands presently excluded from leasing total 2,574,000 acres; status of these and proposed sanctuaries is as follows (Map S-7):

State, existing:

1. San Mateo, San Francisco, Marin, Sonoma, Napa, Alameda, Santa Clara, Del Norte, and portions of Solano and Contra Costa Counties.

2. Humboldt and Mendocino counties - from four miles north of Cape Mendocino to two miles south of the northern boundary of Mendocino County.

3. Santa Cruz and Monterey counties - from the San Mateo-Santa Cruz County boundary to the Monterey County-San Luis Obispo County boundary.

4. San Luis Obispo County.

5. Santa Barbara County - from Goleta to Summerland.

6. Santa Barbara Channel Islands.

7. Los Angeles County - from the Ventura County-Los Angeles County boundary to Point Fermin.

8. Santa Catalina Island.

9. San Clemente Island.

10. Orange and San Diego counties - from the northerly boundary of Newport Beach to the southerly boundary of the state.

State proposed:

1. Humboldt and Mendocino counties - SB198 (Behr)
   Enlarges existing sanctuary to include all state and submerged lands within the counties.

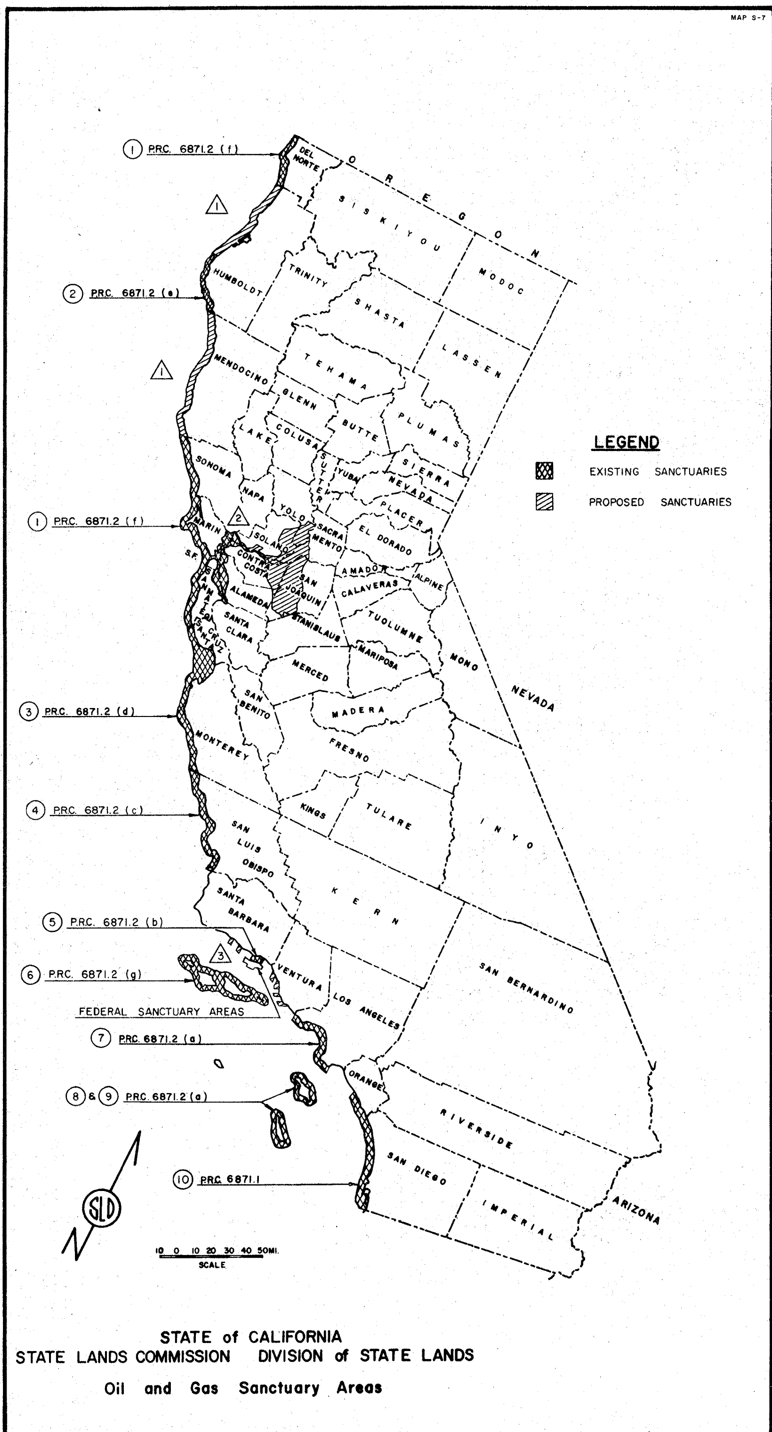
2. San Francisco Bay and Sacramento-San Joaquin Delta Area - SB210 (Nejedly)
   Prohibits oil and gas exploration or extraction on State tide and submerged lands in the San Francisco Bay and the Sacramento-San Joaquin Delta except those under existing contracts, leases or agreements.

3. Santa Barbara and Ventura counties - SB597 (Behr)
   Prohibits any future oil and gas leasing in the Santa Barbara Channel.

4. Santa Barbara and Ventura counties - AB1526 (Moretti)
   Prohibits further oil and gas leasing in the Santa Barbara Channel after April 1, 1972, and authorizes the State Lands Commission to order operations under state lease to cease if such operations constitute an unreasonable risk of pollution.

Federal:

The only federal sanctuary that has been established lies offshore from Santa Barbara County, between Summerland and Elwood. An area adjacent to the state sanctuary offshore from Santa Barbara was excluded from leasing when the federal lands were offered for bid in 1968. An additional area was added to this buffer zone after the federal lease sale. On March 21, 1969, Public Land Order 4587 was published in the Federal Register by Secretary of Interior Walter Hickel. This order provides for the withdrawal of certain lands from all forms of disposition, including mineral leasing, and reserves them for scientific, recreational and other similar uses, such as an ecological preserve. The order also withdraws certain lands from leasing as an adjunct to the ecological preserve.


MAP S-7
1 P.R.C. 6871.2 (f)
2 P.R.C. 6871.2 (e)
1 P.R.C. 6871.2 (f)
3 P.R.C. 6871.2 (d)
4 P.R.C. 6871.2 (c)
5 P.R.C. 6871.2 (b)
6 P.R.C. 6871.2 (g)
FEDERAL SANCTUARY AREAS
7 P.R.C. 6871.2 (a)
8 & 9 P.R.C. 6871.2 (a)
10 P.R.C. 6871.1
LEGEND
EXISTING SANCTUARIES
PROPOSED SANCTUARIES
OREGON
NEVADA
ARIZONA
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
MENDOCINO
TEHAMA
GLENN
BUTTE
PLUMAS
LAKE
COLUSA
SUTTER
YUBA
SIERRA
NEVADA
SONOMA
NAPA
YOLO
PLACER
MARIN
SOLANO
SACRAMENTO
EL DORADO
S.F.
CONTRA COSTA
SAN JOAQUIN
AMADOR
ALPINE
SAN MATEO
ALAMEDA
CALAVERAS
SANTA CRUZ
SANTA CLARA
STANISLAUS
TUOLUMNE
MARIPOSA
MONO
MERCED
SAN BENITO
MADERA
MONTEREY
FRESNO
KINGS
TULARE
INYO
SAN LUIS OBISPO
KERN
SANTA BARBARA
SAN BERNARDINO
VENTURA
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
SLD
10 0 10 20 30 40 50MI.
SCALE
STATE of CALIFORNIA
STATE LANDS COMMISSION DIVISION of STATE LANDS
Oil and Gas Sanctuary Areas

REV. 10-18-71

Proposed: A number of bills have been introduced in the 92nd Congress that would affect oil and gas development in federal waters off California. A few of these bills are described briefly below:

1. S 373 (Cranston, Tunney). Provides for a federal ecological preserve in a portion of the Outer Continental Shelf in the Santa Barbara Channel; cancels certain federal oil and gas leases in the Santa Barbara Channel, and suspends drilling on other federal leases in the Channel.

2. S 1446 through S 1452 (Cranston, Tunney). Create federal marine sanctuaries seaward of existing state sanctuaries.

3. H.R. 2637 (Teague). Provides for a federal ecological preserve in a portion of the Outer Continental Shelf in the Santa Barbara Channel; institutes a moratorium on drilling operations pending the ability to control and prevent pollution by oil discharges.

4. H.R. 6885 (Hanna). Prohibits mineral leasing and geologic or geophysical surveys on federal lands from the northerly city limits of the City of Newport Beach to the southerly boundary of California.

5. H.R. 7991 (Saylor). Terminates certain federal oil and gas leases in the Santa Barbara Channel.

6. The Nixon Administration proposed legislation for rescinding 35 federal lease parcels in the Santa Barbara Channel and creating a national energy reserve. The area is between the Channel Islands and Santa Barbara (Map S-3).

RESUME OF OFFSHORE DEVELOPMENT HISTORY

1896: First offshore production in California at Summerland, Santa Barbara County.

1921: First tidelands leasing act (Chapter 303, Statutes of 1921). Subsequent discovery of oil at Rincon, Elwood and Capitan.

1933: Huntington Beach tideland production established as a result of court-ordered well surveys.

1938: The State Lands Act of 1938 established the State Lands Commission.

1939: First wells drilled into tidelands granted to a municipality at Long Beach (Wilmington field).

1953: Discovery of oil in the offshore area of West Montalvo field. Discovery of oil on granted tidelands in the offshore area of West Newport field.

1954: First man-made island, "Monterey", built one and one-half miles offshore from Seal Beach to develop the Belmont Offshore field.

1955: Cunningham-Shell Tidelands Act restricted leasing to areas of known potentiality. Provided for the erection of drilling platforms.

1956: Oil discovered offshore from Redondo Beach on granted tidelands.

1957: Cunningham-Shell Tidelands Act amended. Specified sliding-scale royalties beginning at not less than 16-2/3 percent.

1958: First permanent drilling platform, "Hazel", erected two miles offshore from Summerland. (Summerland Offshore field). Rincon island constructed with causeway to shore.

1960: Platform Hilda installed west of "Hazel" in the Summerland Offshore field. Platform Helen erected offshore from Gaviota (Cuarta Offshore field).

1961: First well completed on the sea floor (west of Rincon Island). Platform Harry installed one mile offshore from Point Conception (Conception Offshore).

1962: Molino Offshore Gas, Caliente Offshore Gas and the offshore area of Alegria oil field discovered. All wells completed on the sea floor.

1963: Platform Herman installed east of "Harry" (Conception Offshore field). Platform Emmy erected one and one-quarter miles offshore from Huntington Beach.

1964: Platform Eva installed west of "Emmy" (offshore area of Huntington Beach field). Legislation passed to develop the eastern portion of Wilmington field on tidelands granted to the City of Long Beach (Senate Bill No. 60, Ch. 138, Statutes of 1964, 1st E. S.). Subsequently, four islands, "Chaffee", "Grissom", "White" and "Freeman", were built in the inner Long Beach Harbor.

1965: Island Esther built east of Island Monterey (Belmont Offshore field). Platform Hope erected three miles offshore from Carpinteria (Carpinteria Offshore field).

1966: First federal lease issued in the Santa Barbara Channel (federal portion of Carpinteria Offshore field). Platform Heidi erected east of "Hope". Oil discovered offshore from Venice Beach (Venice Beach field) on tidelands granted to the City of Los Angeles.

1967: Platforms Hogan and Houchin installed on Federal OCS Tract 298 (federal portion of Carpinteria Offshore field).

1968: Federal Bureau of Land Management leased 71 tracts in the Santa Barbara Channel for a total cash bonus payment of $602,719,261. Platforms A and B erected on Federal OCS Tract 402 (Dos Cuadras field).

1969: Well blowout on Platform A. Federal ban on all drilling in the Santa Barbara Channel. Drilling later resumed. All new drilling on state-owned tidelands banned subject to State Lands Commission review. Platform Hillhouse installed on Federal OCS Tract 401 (Dos Cuadras field).

1971: Secretary of the Interior refuses permission to erect additional platforms on Federal OCS Tract 401 and 402 (Dos Cuadras field).

On state-owned offshore lands, the ban on drilling new wells imposed in February 1969 by the State Lands Commission remains in effect. Under the Commision's policy, two new wells have been drilled from Island "Esther" where unique conditions of drilling safety exist. No other new wells have been drilled on state-owned offshore lands. On lands granted to coastal cities, development is continuing. Oil and gas is being produced from state-owned and granted lands at average daily rates of 217,000 barrels of oil and 161,000 Mcf. of gas. Of the 72 tracts in federal waters in Santa Barbara Channel, 33 have been cleared for drilling and drilling is being conducted on four of these tracts. Production from the fields in federal waters, Dos Cuadras and a portion of Carpinteria, is approximately 90,000 barrels per day.

Humble Oil and Refining Company has reported major oil discoveries on Tracts 325, 332, 334, and 342. These tracts are three to five miles offshore and extend from Point Conception to Gaviota. Mobil Oil Corporation has reported an oil discovery on Tract 350, three miles offshore from Oxnard, Ventura County.

DRILLING AND PRODUCTION TECHNOLOGY

Current Practices

The basic methods of offshore drilling can be classified as fixed or mobile drillsites. Fixed drillsites include conventional onshore equipment with holes drilled to the offshore oil zones, man-made islands, and permanent platforms. Mobile drillsites include self-elevating platforms and moored or free-floating vessels. Each method has qualities that are suited to varying water depths, number of wells to be drilled, properties of the hydrocarbon to be produced and degree of permanency required.

Producing equipment for wells drilled from fixed locations is essentially land-type, whereas the producing equipment for wells drilled from mobile locations is uniquely marine. The latter is designed to be placed on the ocean floor and can be operated remotely or by divers. Sea floor completions have proven successful for gas wells, which require little attention; but the systems are not yet totally proven for oil operations.

A new series of pump-down tools has recently been developed that enables remedial work to be done on a well without the use of a diver. Operations such as paraffin removal, squeeze cementing, acidizing, plastic sand consolidation and reperforating can now be performed by tools that are pumped down the tubing and retrieved by hydraulic pressure. Deep sea divers are frequently required for the many mechanical operations on the sea floor that are too complicated for remotely controlled devices. Greater understanding of the physiology of the human being under pressure has led to an increase in the working depth capability of divers to 600 feet, and that depth may soon extend to 700 or 800 feet. Sea floor production installations along the California coast to date have not required diving to more than 250 feet.

New Underwater Operating Concepts

Combinations of sea floor well equipment and surface platforms, floating and underwater storage, oil handling and well completion systems are being considered. Possible methods include:

Submerged Platform - Would contain built-in artifical lift and production piping. Structure would support subsea wellheads at diver- accessible depths. Storage would be on a nearby floating vessel or small platform.

Conventional Fixed Platforms - Structure would contain wells, production equipment and storage facilities, and would also handle additional production from nearby subsea wells.

Floating Storage and Crude Handling - This could be a version of the single point tanker mooring system or involve semisubmersible tanks. Bottom-completed subsea wells would produce through special systems to these permanently anchored installations.

Underwater Storage and Processing - Concrete underwater storage tanks and a subsea processing facility accessible from the surface without diving equipment.

Safety, and Prevention of Pollution

Fire and accident prevention are of the utmost importance on offshore drilling and producing facilities. Highly specialized equipment and alarm systems are used to reduce the possibility of a mishap.

The industry in California, under self-imposed rules and regulation by state agencies has an enviable record of operation. From 1957 through 1968, 682 wells were drilled from platforms, piers, islands, and fixed or floating structures on state offshore leases under state regulations and jurisdiction; other wells were slant-drilled into offshore lands from upland drillsites. In addition, 708 offshore coreholes were drilled under state regulations and supervision from May 1956 through January 1969; 465 of these coreholes were drilled on what have now been designated Federal O.C.S. lands. *No significant oil spill resulted from the drilling of any of these wells.* This excellent record was not the result of simple good fortune. California began regulating oil operations in 1915; since that time, a vast background of experience has been gained from drilling approximately 90,000 wells in the state.

Well Control

In the rotary system of oil well drilling, formation fluids are confined to their respective zones by drilling mud which exerts a hydrostatic pressure greater than the formation pressures in the well bore. This is the primary method of well control; blowout prevention equipment is secondary and its function is to preserve the fluid (mud) column or confine well fluids to the well until an effective fluid column can be restored.

Blowout-Prevention Equipment

Blowout-prevention equipment, commonly referred to as BOPE, is basically a valve-type mechanism to prevent escape of fluids or equipment from the hole. In other words, turn the well off.

Another specialized piece of equipment used to prevent leaks during oil production is an automatic valve called a "storm choke". On flowing wells, the Division of Oil and Gas requires that a storm choke be installed about 100 feet down the well and set to shut in the well if there is a pressure drop. There are also surface valves, often remotely located, that can shut in wells. One master valve can close down all wells and all offshore shut-in valves can be activiated automatically by remote control from shore. This equipment is tested before and after installation and during operation.

ESTHETICS

As long as the offshore petroleum resources are developed from structures erected in the water, there cannot be complete compatibility of such operations with the esthetic value of the scenic coastline for all people.

Portions of the offshore area were closed to leasing by the Cunningham-Shell Tidelands Act of 1955 which was based on a need to protect the traditional scenic and recreational use of the coast during the development period of petroleum resources in tide and submerged lands. It prohibited any type of operation that could result in interference with, or impairment of, shoreline recreational or residential areas.

Beautification efforts have been made in recent years by members of the petroleum industry in areas where operations might offend the esthetic values of some people. Many cities have zoning and building ordinances which require drilling and production facilities to harmonize with the surrounding areas. One such project, a man-made island in Long Beach Harbor, is shown on Figure S-1. Figure S-2 shows a lighthouse structure which housed a drilling rig. The producing facilities of many of the wells in the Wilmington field have been placed in cellars so that there is no impairment of the scenic seascape.

These efforts, which have been costly, have been effected only recently. In prior years bad housekeeping and retention of unused equipment have degraded many areas. Figure S-3 is a coastline example of this.

ECOLOGICAL IMPACT

Although offshore petroleum development operations have, in a few instances, resulted in harmful effects to the marine environment, there have been many ecological impacts from these operations that have been beneficial.

A three-year study conducted by the Department of Fish and Game, beginning in May 1958, evaluated the effects on marine life of offshore drilling, and attendant man-made structures, and of depositing washed drill-cuttings on the ocean floor. Marine organisms associated with four drilling platforms and a man-made island were investigated. All drilling sites showed similar attractions for fishes, as the sites serve as artificial reefs.

Encrusting organisms rapidly covered all exposed underwater areas of the platforms and either provided food for fish, or sheltered forms that did. Fish populations grew from a few scattered individuals to several thousand semiresidents. The deeper water platforms attracted schooling fishes and several species of rockfish that were not associated with the inshore areas. Fish populations increased rapidly during the first year the installations were in place, and then showed fluctuations apparently correlated to temperature, season, or other natural factors.

This study showed that establishing offshore, oil-drilling installations was generally beneficial to the marine habitat, and depositing washed drill-cuttings on the bottom at installation sites had no effect on marine life.

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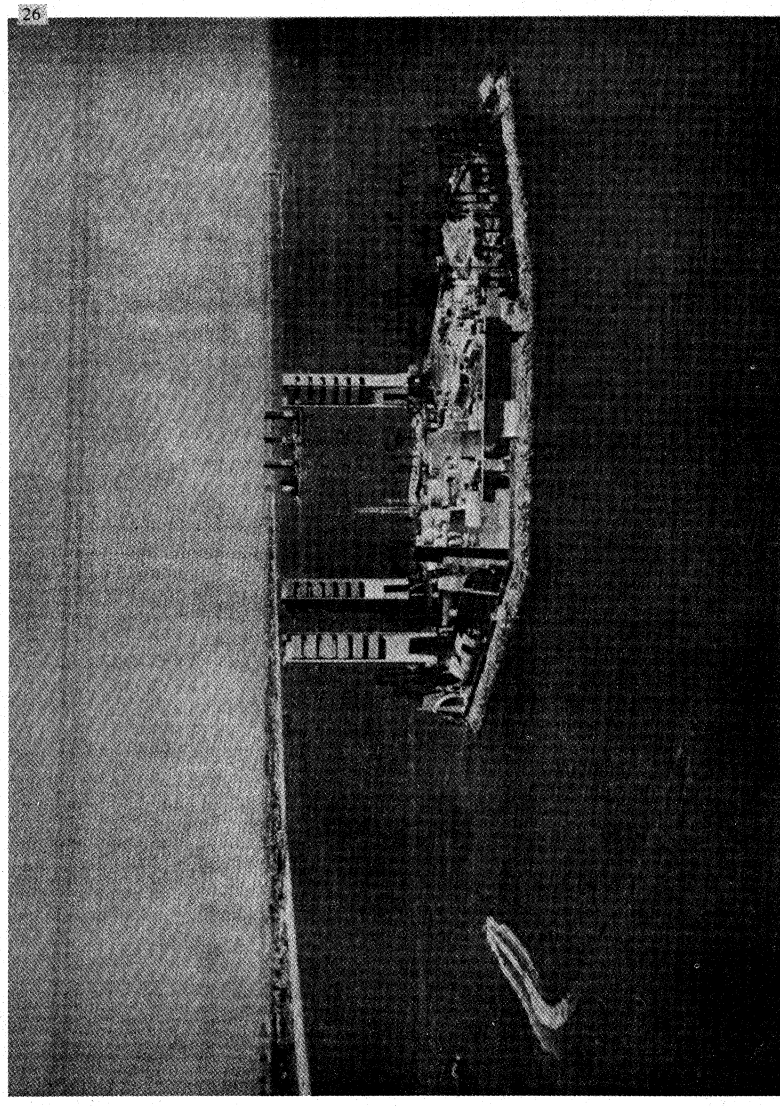


Man-made drilling island in Long Beach Harbor.

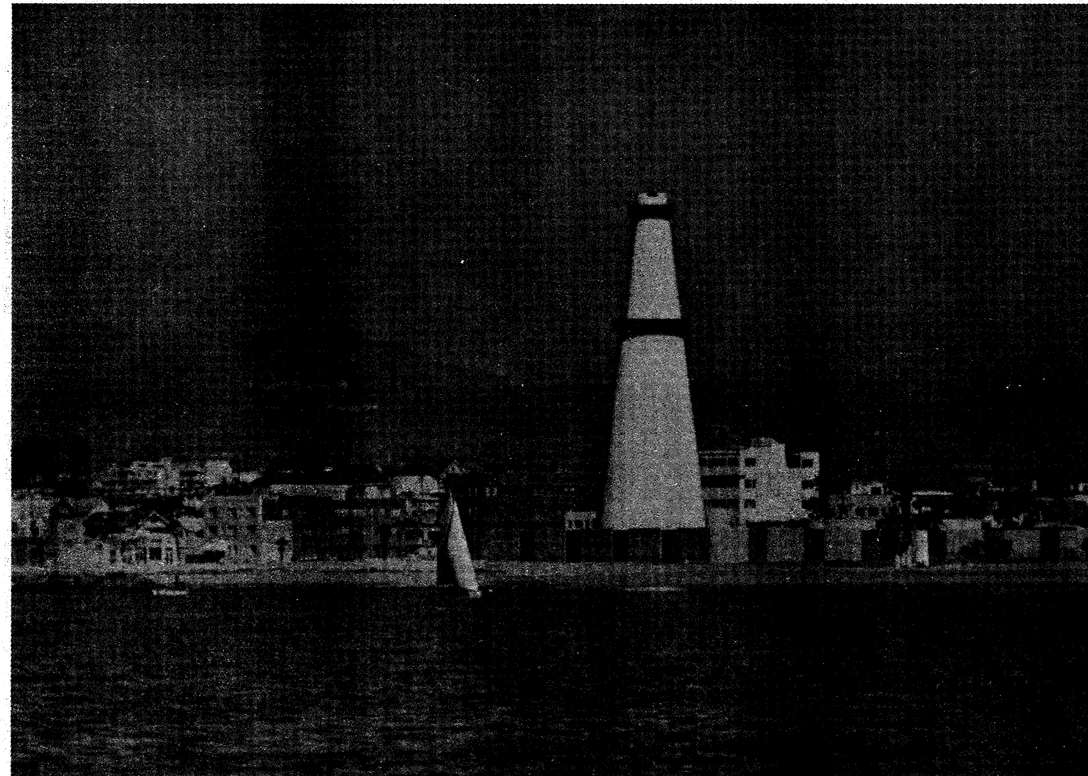


Figure S-2 **Mobil Oil Corporation drilling rig disguised as a lighthouse and used for development of Venice Beach offshore field.**

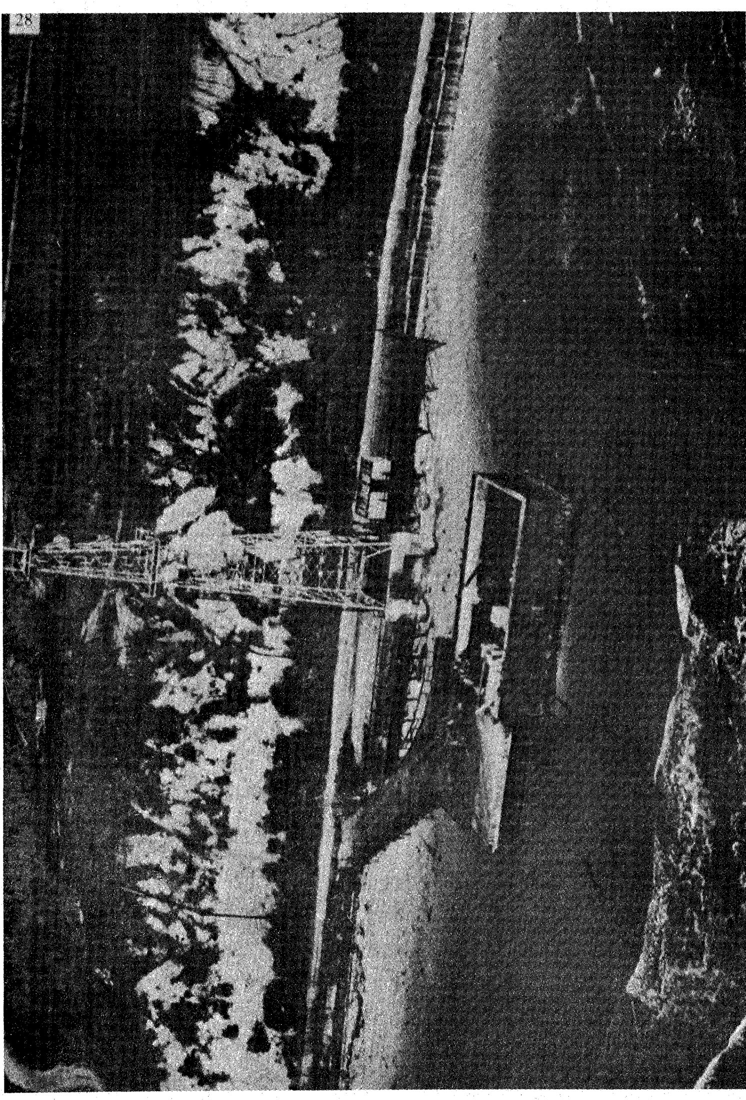


Figure S-3 **Deserted oil well along Southern California coast.**

The important danger arising from offshore oil operations is that of an oil well blowout or oil spill. The primary danger to marine life is from a petroleum tanker accident. There are a number of factors that govern the impact of such an incident on the living marine resources. Exclusive of volume, the most important are the physical properties of the petroleum involved, and the length of time it is in the sea. If the oil can be contained and removed quickly, there is little damage to marine life. Crude oil carries aromatic and volatile constituents that are toxic to marine life, but these evaporate in a few days and the danger is reduced. The oil mixes with water, forming emulsions that float and are sticky and viscous, and can coat floating or intertidal organisms. Oil that is not emulsified is degraded by spontaneous oxidation, and more importantly, by biological oxidation. Over varying periods of time the oil will be removed by these processes. Refined products such as fuel oil can be highly toxic; they sometimes form sand-oil sludge that smothers bottom life. This was the case when the tanker TAMPICO MARU went aground in 1957 off the west coast of Baja California. Twenty thousand barrels of diesel oil gushed into the sea. Dead animals were common on the beaches and piles of dead sea urchins and mussels accumulated near the wreck. Ten years later, the ecology of the area still had not returned to normal.

Other factors are the opportunities for the oil to disperse in the open sea, and the methods used to contain and clean up the spill. The chemical methods used in the TORREY CANYON spill off England, resulted in an estimated 10 percent loss of marine life in a fairly large area.

In the spill off Santa Barbara, crude oil was involved. A dispersant was used at and near the site. Straw was spread on the inshore waters to soak up the oil. The beaches and inshore waters also had large quantities of debris on them, as a result of the January 1969 floods, which helped absorb oil. Cleanup operations were confined to the mainland shore and consisted of removing oil-soaked straw and debris, and cleaning oil off rocks by steaming or sandblasting.

The major damage to the marine life occurred along the shoreline, and some of this was the result of cleanup operations. The use of steam and sandblasting to clean rocks took a high toll in attached organisms. At Anacapa and Santa Cruz Islands, where no cleanup operations occurred, the attached organisms were covered by a thin layer of oil and there some loss of biota occurred. Natural recovery of animal and plant colonies in these areas has been rapid.

It is conjectural how much damage was done to marine mammals. Four dead porpoises, several seals and six dead whales washed ashore after the leak began. Some of the animals, when found on the beach, were coated with crude oil, but subsequent examinations, including autopsies, have not linked the deaths to oil contamination.

The Department of Fish and Game estimated that 3,700 birds were killed, most of them western grebes, as a result of the spill. The Department also reported no influx or exodus of birds in the area, and that most birds appeared to avoid oil-contaminated areas.

Diving surveys indicated that several species of marine plants in the near-shore zone at Santa Cruz and Anacapa Islands incurred some damage from oil, but these plants had completely returned to their former abundance within a year. Plants with a gelatinous coating appeared not to be affected, whereas species with a rough surface were; apparently oil was able to adhere to the latter. Only those plants that live in the intertidal area where they could come in contact with the oil floating on the surface were affected. Other organisms in the near-shore zone appeared normal and healthy, even though some were covered with oil.

Trawling surveys and bottom-grab samples indicated all sampled fish and invertebrates occurring in the bottom zone remained in good condition and were not affected by the oil. There was no indication, from the samples taken, that the food-web had been impaired in any way. Plankton, larvae, and sonic surveys indicated the same was true for the pelagic resources.

A good sign that the marine life in the area has not been too adversely affected by the Santa Barbara oil spill is that the diversity of species has remained high. During January and February 30 inches of rain fell along the Santa Barbara coast resulting in an influx of fresh water carrying debris and sediment into the coastal waters. The only adverse effect that can be definitely attributed to this was that a large number of wavy turban shells were washed ashore at Carpinteria, an area hard hit by the flooding.

The many natural, subsea oil seeps in the Channel area have not affected the marine life. Abundant bottom life exists practically on top of active seeps. The life in these areas has a preexisting or perhaps evolved tolerance for certain quantities of petroleum. On San Miguel Island, a portion of the shore is covered with oil as a result of nearby natural seeps; the sea mammals that live there have adapted to this condition. Because of the seeps there could also be a higher population of oil degrading bacteria normally present in the Santa Barbara Channel than is normally found in other areas.

All marine biologists do not agree on the ecological impact of an oil spill. A study financed by the Federal Water Quality Administration and conducted by a professor of biology at University of California, Santa Barbara, apparently concludes that there are long range effects of the Santa Barbara incident that cannot yet be assessed. Some scientists at Woods Hole Oceanographic Institution feel that the subtle ecological effects are still unclear.

SPILL CONTAINMENT CAPABILITY

Containment Methods

Containment of an oil spill on water is primarily dependent on wind and sea conditions. Calm water areas seem to be well-suited for the boom method of containment. Conditions on the open sea can change rapidly and therefore exceed the capability of any presently known method.

Wind (15 knots) and sea conditions (2-foot or higher waves) are the critical factors affecting oil-containment and recovery devices. Many times during a year, conditions off the California coast exceed these factors.

Booms are the primary method of containment. A boom is essentially a floating fence consisting of linked buoyant chambers with a weighted skirt. Buoyancy may be provided by air or, more commonly, by a polyvinyl chloride foam. The weighted skirt of vinyl-treated fabric hangs below each buoyant segment. Recent tests indicate that booms are ineffective in waves over 2 feet in height, and where currents are in excess of about one knot. Booms do appear to be effective when used in harbors or offshore to deflect the movement of an oil slick towards a preferred point, thus avoiding the difficulty encountered with a direct in-line barrier downwind from the spill source.

A *"bubble boom" or "bubble curtain"* is formed by bubbles of air rising from a perforated tube lying on the sea floor, or suspended below the water surface. The rising bubbles cause an upwelling current to be generated on both sides of the "curtain". At the surface, these currents move away from the bubble line opposing the movement of an oil slick on the surface. The effective use of this type of barrier is limited to calm harbor waters where the current does not exceed one knot.

Underwater tents are currently being used in the Santa Barbara Channel to capture and recover oil leaking from the sea floor. The tents consist of a coated nylon fabric attached to a metal frame anchored to the sea floor. Oil collects under the tent and rises through a hose to the surface where it is collected and shipped ashore. The system is somewhat vulnerable to sea turbulence but, when intact, provides at present the only known method of sea-floor seep containment.

Recovery Methods

There are a number of systems available to remove oil from the surface of water. Surface conditions compatible with present methods are generally found only in protected areas. Consequently, none of the devices has performed satisfactorily under conditions normally found on the open sea.

Fire The removal of oil from the water surface by burning is relatively quick and inexpensive. However, this method cannot be used where over-water structures, harbor facilities or vessels would be damaged, or in the vicinity of wells where flammable gas might be present.

Past experience indicates that igniting the oil is difficult, owing to the relatively high flash-point of most crude oils and the rapid heat loss of a thin oil film on a cold-water surface. In addition, an adequate supply of oxygen is necessary to promote continued combustion. Commerical products are now being marketed that reportedly provide the heat insulation- and-wicking action needed to promote ignition and maintain continued combustion.

Skimmers are the principal mechanical devices currently used to recover oil from the water surface. They are either modified boats or barges. The machine is designed to skim oil off the surface, collecting as little sea water as possible. The oil and water flow into a separator; the oil is retained and the sea water discharged.

Suction or vacuum heads have been found useful in near-shore clean- up operations or in harbors where oil has collected in areas inaccessible to other types of equipment. Equipment may consist of an oil field vacuum or sump truck mounted on a barge or moving along the shoreline.

Chemicals have been developed that cause oil to disperse in the open sea. Others cause the oil to coagulate or gel around the perimeter of an oil slick, thereby forming a kind of barrier to contain the slick. This method has had only moderate success in calm waters. Other chemicals are being tested that reduce the surface tension of the water and cause the oil to consolidate instead of spreading over the water surface, thus aiding skimming by increasing oil thickness and concentration.

Spill Contingency Plan

As the potential for an accident, similar to the massive spill caused by the tanker TORREY CANYON, to occur off the coast of the United States became apparent, the President directed various federal agencies to prepare for such an emergency and, as a result, the "National Oil and Hazardous Substances Pollution Contingency Plan" was prepared and became operational in September 1968. The plan promotes coordination and direction of federal, state and local response systems and encourages the development of local government and private capability to handle such pollution incidents. The plan establishes the U. S. Coast Guard as the principal agency in charge of combating oil spills which occur in the offshore environment. Following the Santa Barbara incident of early 1969, the state replaced the then existing 1968 "Marine Chemical Spill Disaster Plan" with the present "California Oil Spill Disaster Contingency Plan".

The state's present plan can function either independently, more effectively, with the U. S. Coast Guard, or within the national contingency plan organization. In addition, the new plan also created a State Interagency Oil Spill Committee that meets periodically to ensure that the plan is updated and includes the latest developments in control technique.

Sources of Oil Spills

A recent study was made of oil spills which have occurred throughout the world during the period 1956 to 1969. The study was confined to major spills in the ocean. Fully 75 percent of all major spills originated from vessels, and of these, 90 percent were from tankers. Three spills were from refineries and two spills were attributed to offshore drilling operations, one of which occurred off the coast of California. There have been no significant spills from offshore pipelines.

The volume of oil spilled ranged from the arbitrarily established minimum of 2,000 barrels to the 700,000 barrels involved in the wreck of the tanker TORREY CANYON. About 70 percent of all spills were over 5,000 barrels and approximately half of all spills occurred within one mile of shore. Three out of four spills occurred within 10 miles of port; this indicates that shallow waters and coverging shipping lanes provide the greatest opportunity for accidents. (see Figure S-4).

Pipelines connect each offshore, subsea, completed oil and gas well with central gathering or production platforms, and also connect all production platforms with onshore facilities. Product lines (water and fuel) also connect platforms and drilling islands with shore. As a consequence, pipelines are numerous and extensive. Although at first pipelines appear to be vulnerable, there has been no known oil leak of any significance (volume) from any pipeline along the California coast, although there are several hundred barrels of oil in each mile of pipeline.

NAVIGATION AND OCEAN TRAFFIC

Shipping Lanes

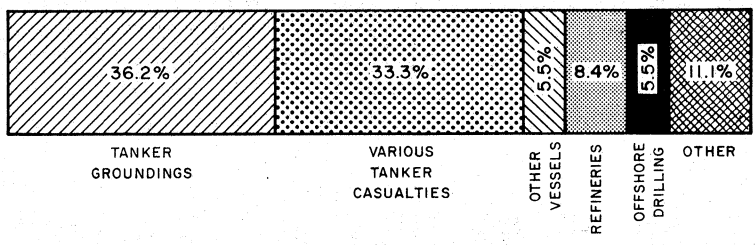
The recommended one-way, vessel traffic lanes in the Santa Barbara Channel consist of a northbound and a southbound lane with a separation zone between the two. The lanes are approximately one mile wide, and the separation zone is about two miles wide (Map S-8). These lanes are for the use of all vessels; however, they are used primarily by merchant marine and government vessels.

The platform closest to the recommended traffic lanes are approximately five miles away; these are Platforms Harry and Herman, southeast of Point Conception.

All platforms are shown on Coast and Geodetic Survey charts. They are equipped with a quick-flashing white light at each corner and a fog signal sounding a 2-second blast every 20 seconds; additionally, the platforms have high visibility on radar. The above factors make platforms navigational aids; in fact, they are used as markers for boat races. The Department of Navigation and Ocean Development has yet to receive a boating accident report involving a platform.

SOURCE OF SPILL — DATA FROM 36 INCIDENTS

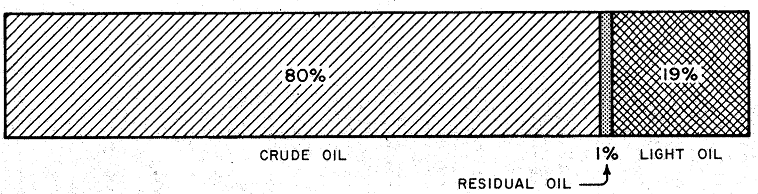
PERCENT OF TOTAL SPILLS



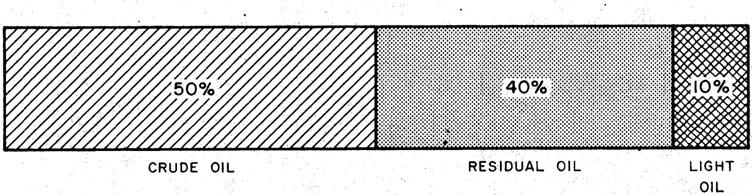
AFTER THE OIL & GAS JOURNAL VOL 68, NO 23, 1970

TYPE OF PETROLEUM SPILLED — DATA FROM 35 INCIDENTS

PERCENT OF OIL SPILLED

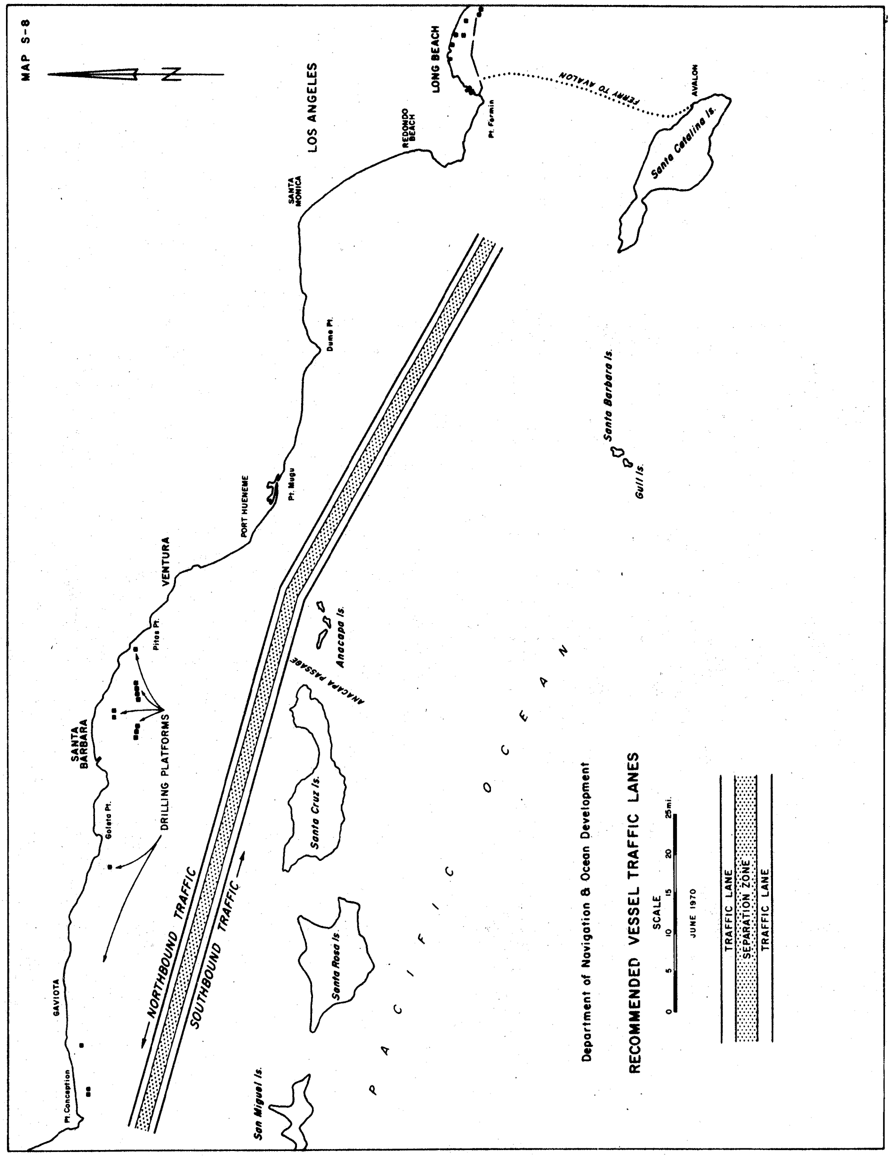


PERCENT OF TOTAL SPILLS



DATA FROM THE OIL & GAS JOURNAL, AND OTHER SOURCES

Figure S-4
(33)


MAP S-8
N
LOS ANGELES
LONG BEACH
REDONDO BEACH
Pt. Fermin
FERRY TO AVALON
AVALON
Santa Catalina Is.
SANTA MONICA
Dume Pt.
Santa Barbara Is.
Gull Is.
Pt. Mugu
PORT HUENEME
VENTURA
Pitas Pt.
Anacapa Is.
ANACAPA PASSAGE
DRILLING PLATFORMS
SANTA BARBARA
Goleta Pt.
Santa Cruz Is.
Santa Rosa Is.
San Miguel Is.
GAVIOTA
Pt. Conception
NORTHBOUND TRAFFIC
SOUTHBOUND TRAFFIC
P A C I F I C O C E A N
Department of Navigation & Ocean Development
RECOMMENDED VESSEL TRAFFIC LANES
SCALE
0 5 10 15 20 25mi.
JUNE 1970
TRAFFIC LANE
SEPARATION ZONE
TRAFFIC LANE

Statement of Charles F. Lambeth, Jr., President American Freedom Association, Inc.

The American Freedom Association is a non-profit educational organization which has existed since 1953. It is dedicated to the principle of achieving world peace through the process of world law. There are approximately three hundred members of this organization, most of whom live in the two Carolinas and Virginia. I am also a member, together with thousands of lawyers from the United States and throughout the world, of the World Peace Through Law Center. While I do not speak for that organization, I admire its Draft Treaty Governing the Exploration and Exploitation of the Ocean Bed (1971) which closely parallels the draft, submitted by the United States, of a United Nations Convention on the International Seabed Area.

The United States plan proposes that the international area shall comprise the entire seabed area beyond the 200 meter depth, and that this area shall be the common heritage of all mankind. It provides for coastal State Trusteeship in the area beyond a depth of 200 meters embracing the continental margin, and establishes the responsibilities and rights of the Trustee State. This proposal was submitted to the United Nations Seabed Committee in 1970 and has provided the chief basis for optimism among states and individuals who desire to see the resources of the ocean developed in a peaceful, orderly way. In the short run the plan of the United States might rightfully be conceived as a magnamimous gesture on the part of a highly developed nation, which otherwise, with its technology, could exploit the seabed to a far greater extent than the underdeveloped nations. In the long run, however, the United States plan will prevent chaos, prevent pollution, provide a fair share of the ocean's resources to all nations, prevent the widening of the gap between rich and poor nations, and will be a strong factor in the development of a peaceful world.

In December of 1969 the United Nations adopted a resolution to the effect that pending the establishment of an international regime, "States and persons, physical or juridical, are bound to refrain from all activities of exploitation of the resources of the area of the seabed and ocean floor, and the subsoil thereof, beyond the limits of national jurisdiction" and that "No claim to any part of that area or its resources shall be recognized. . . ." The United States should adhere to this moratorium because it is consonant with our proposed Draft Treaty and because it makes common sense. If American and multinational oil interests seek to apply "rights" to the sea bottom on a "first come, first served" basis we will have, in essence, a sort of Oklahoma land rush for the mineral resources of the ocean floor. We can expect the developed socialist countries, including the Soviet Union, to join the rush. This is no way to develop world order.

An ocean regime similar to the one proposed by the United States will face problems which the United Nations has struggled with. However, the ocean regime begins with a unique advantage. No human beings yet live in the ocean, and therefore there are no vested political interests or accumulated grievances. Injustices which it must contend with have not yet occurred. The job of the ocean regime will be preventive, not corrective.

It is urged that this Committee refrain from jeopardizing the chances of an orderly development of the seabed by granting leases beyond the 200 meter depth.

STATEMENT SUBMITTED BY MAX BLUMER, SENIOR SCIENTIST, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole Oceanographic Institution,
Woods Hole, Mass., April 14, 1972.

Senator Henry M. Jackson,
Chairman, U.S. Senate, Committee on Interior and Insular Affairs,
Washington, D.C.

Dear Senator Jackson: Thank you for your letter of April 6, 1972, in which you ask me to submit a statement regarding "outer continental shelf" policies and issues. I believe that I can best serve you and your committee in submitting for the record, information on the effects and persistence of marine oil pollution, such as it will necessarily result from extended offshore oil exploration and production. I consider the following documents relevant:

Two papers, *Scientific Aspects of Oil Pollution*, and *Oil Contamination and the Living Resources of the Sea*, present background data on the composition and environmental toxicity of oil and on its hazard for marine resources.

You may remember the relatively small oil spill which occurred in Cape Cod waters at West Falmouth in September 1969. Our studies of the effect and persistence of that spill are summarized in: *The West Falmouth Oil Spill* and *A Small Oil Spill.* I enclose a preliminary copy of the most current report: *The West Falmouth Oil Spill, Data Available After Two Years.* A final copy of the report will be sent to you shortly. The most important results of this study are summarized in: *Persistence and Degradation of Spilled Fuel Oil.*

Oil enters the marine food web and returns to us in fisheries products. Persistent oil pollution has been demonstrated in shellfish: *Determination of Polycyclic Aromatic Hydrocarbons in Oysters Collected in Polluted Water; Hydrocarbon Pollution of Edible Shellfish by an Oil Spill*, and *Petroleum Hydrocarbons in Oysters from Galveston Bay.* Similarly, other investigators have found pollution, resulting from hydrocarbons in refinery effluents, that has accumulated in finfish: *Kerosene-like Tainting in Australian Mullet.*

Sensitive methods permit the detection of oil pollution in contaminated sediments and organisms. We have reviewed these techniques in: *Petroleum*, an FAO Panel Report, and we have described the application of these methods to define extent and persistence of the pollution at West Falmouth, in: *Indigenous and Petroleum Derived Hydrocarbons in a Polluted Sediment.*

Some have argued that other spills, elsewhere, have caused less damage than the West Falmouth spill; a report on the Santa Barbara disaster is often quoted in that context. Contrary to that, we feel that both studies agree in their findings on the persistence of the oil. Apparent differences in the biological impact seem to be the result of differences in the techniques used for the study rather than in the biological effect of the oil. We have elaborated on this important point in a *Letter to the Maine Environmental Improvement Commission*, in connection with the hearings at Searsport. Newer publications on the Santa Barbara spill indicate that there has been considerable biological damage and that such spills present potential long-term dangers for the coastal ecology.

Surprisingly, there have been no attempts to follow the fate and eventual dissipation of spilled oil in the marine environment. Our West Falmouth study now extends over 2½ years and shows that the oil from the 1969 spill still is not dissipated. We have studied similarly the fate of oil on the beaches at Martha's Vineyard, Mass. and at Bermuda and find little weathering and full rention of the crude oil character 13½ and 16 months after the stranding of the oil: *The Environmental Fate of Stranded Crude Oil.*

We have attempted to assess the effect of oil on the coastal and near shore ecology in three Congressional *Testimonies* (enclosed).

I believe that the hazard of oil pollution to the marine ecology is greater than was thought. Unfortunately, the existing sensitive techniques which permit an assessment of the persistence and of the effect of oil have had little use in the past. For instance, there are no quantitative data from regions of active oil production, offshore or from major oil ports, on the degree of oil pollution of the sea bottom of the marine food chain and of the fisheries resources; nor are there sufficiently extensive biological data.

Methods to study these effects exist and we should assess our performance in existing offshore oil fields, before we extend our operations to clean areas.

The U.S. Department of the Interior requires that oil shale exploitation in the western states must be preceded by ecological baseline studies, and more importantly, that the production quota shall be tied directly to the environmental status. A similar policy, which we suggested in earlier testimony, should be adopted with regard to offshore oil production. The marine environment can tolerate a *limited* amount of pollution. Beyond that, damage results and the pollution becomes increasingly persistent. To avoid the resulting environmental deterioration we must measure pollution levels and reduce, if necessary, the quantity of pollutant that reaches the sea. I appreciate your concern and your efforts in this critical area and acknowledge gratefully the continued support of my research by the National Science Foundation, the Office of Naval Research and the Environmental Protection Agency.

Sincerely yours,

MAX BLUMER, *Senior Scientist.*

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ORGANISATION DES NATIONS UNIES POUR L'ALIMENTATION ET L'AGRICULTURE
ORGANIZACION DE LAS NACIONES UNIDAS PARA LA AGRICULTURA Y LA ALIMENTACION

FIR : MP/70/R-1
14 September 1970

FAO TECHNICAL CONFERENCE ON MARINE POLLUTION AND ITS EFFECTS ON LIVING RESOURCES AND FISHING

Rome, Italy
9-18 December 1970

OIL CONTAMINATION AND THE LIVING RESOURCES OF THE SEA

by

M. BLUMER
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543, U. S. A.

Contents

1 COASTAL WATERS - MULTIPLE USES

Throughout history man has used the ocean, especially the coastal waters, as a source of food and minerals, and for shipping and waste disposal. Today, more than ever, the ocean has a very large tangible and intangible value and an even greater potential. The present annual world income from marine fishing is now roughly $8 billion. The world ocean freight bill is nearly twice that. In contrast, the mineral recovery has a relatively small value, the world oil and gas production from the seabed is worth approximately half that of the fish catch, and all other mineral production adds only $250 million (Holt, 1969). The value of the ocean for recreation and for waste disposal is not easily put into similar figures; as a source of oxygen and through its interaction with the terrestrial ecosystems a healthy ocean may well have critical importance for the survival of the human species.

The economic and esthetic potential of the coastal regions is far greater than we realize now; it has been estimated that with presently available technology Puget Sound alone could produce annually 6 million lb of oyster meat, equal in value to the entire present U.S. fish catch (Westley, 1967). The coastal waters produce almost the entire shellfish crop and nearly half of the total fish crop; the remainder comes from regions of upwelling waters that occupy one-tenth of one percent of the ocean surface and that are located near the margins of some continents. Similarly, recreational values, oil and mineral resources and marine waste disposal areas are concentrated almost entirely in the coastal regions of the ocean.

2 COASTAL WATERS - MULTIPLE STRESSES

Our growing population and our expanding technology lead to an increasing dependence on marine values and resources. Different uses of the coastal environment are often in conflict and are being made and planned with little regard for the marine environment as a large interrelated ecosystem. Of necessity, this stresses the environment and may lead to unanticipated and potentially irreversible harm. These stresses come from many unrelated sources; among these are the loss of marshland, the disposal of domestic and industrial wastes, pollution by persistent chemicals, overfishing, destruction of productive habitats by dredging, water diversion resulting in changes in the nutrient balance and - not the least - oil pollution, the subject of this paper.

The marine environment is tolerant of changes - up to a point. Many individual actions and even single large stresses can be tolerated; whether this is still true for the sum of the stresses imposed on the environment now should be a matter of great common concern. We have polluted many of our rivers and lakes, including some large bodies of water like Lake Erie. The wastes that now enter the coastal regions of the ocean are similar to those that have damaged the Great Lakes; in fact they are probably more toxic and more persistent. Given the same damaging input, the ocean differs from the lakes principally only in its size and time constant; changes may take a much longer time to become evident but, as a direct consequence, restoration of a polluted ocean will also require an entirely different time scale. A polluted small lake can be reclaimed within a few years. Lake Erie may or may not be restored within 50 years, but a polluted ocean will remain irreversibly damaged for many generations.

Ketchum (1970) has pointed out "that nature has a tremendous capacity to recover from the abuses of pollution, so long as the rate of addition does not exceed the rate of recovery of the environment. When this limit is exceeded, however, the deterioration of the environment is rapid and sometimes irreversible."

It is not within the scope of this paper to consider the entire field of marine pollution; the further discussion is restricted to the problem of marine, especially coastal, oil pollution because of the increasing extent of oil spillage and because of its severe, but largely unrecognized, biological effects.

3 OIL POLLUTION - EXTENT

Oil pollution is the almost inevitable consequence of our dependence on an oil-based technology. The use of a natural resource without losses is nearly impossible and environmental pollution occurs through intentional disposal or through inadvertent losses in production, transportation, refining and use. Large catastrophes like that of the TORREY CANYON, the blow-outs at Santa Barbara and in the Gulf of Mexico get the attention of the public because of the obvious esthetic damage and the harm to birds. Small and continuing spills and their far greater impact on less visible resources are less apparent to the public. It is estimated that annually 10,000 pollution incidents occur in U.S. waters and that oil pollution accounts for 7,500 of these. We have estimated that the total influx of oil to the ocean through shipping and by accidents in port is at least 1 million metric tons/year (Blumer, 1969). This does not include major catastrophes in production and at sea, unburned fuel, spent lubricants and a significant hydrocarbon contribution entering the sea from land based sources, e.g. in municipal wastes. Thus, the total hydrocarbon influx to the ocean may be as high as 10 million metric tons. Most of this influx of hydrocarbons takes place in coastal regions and contributes to the stress on our most productive areas of the ocean.

4 OIL - COMPOSITION AND PERSISTENCE

Petroleum is one of the most complex natural materials and contains many thousand different compounds. Different crude oils differ markedly in their physical properties, such as specific gravity, viscosity and boiling point distribution. It is beyond the scope of this paper to describe the crude oil composition more than superficially (Blumer, 1969 and reviews in: Eglinton and Murphy, 1969). However, for our discussion, considerable simplification is possible since every crude oil contains the same homologous series of closely related compounds. Different crudes differ mainly in the relative contribution of the individual member of these series. However, within these homologous series, chemical properties and toxicity vary little. Thus, low and high boiling saturated and aromatic hydrocarbons occur in every crude oil and though their numbers may go into thousands, individual members of these series have very similar chemical and biological properties (Blumer, 1969). It follows that in their chemical, biological and toxicological properties crude oils are very similar, in spite of marked differences in individual composition and overall physical properties.

Petroleum and petroleum hydrocarbons in the marine environment are remarkably stable. Hydrocarbons that are dissolved in the water column are eventually destroyed by bacterial attack, though it should be pointed out that it is the most toxic compounds that are also the most refractory ones.

We have demonstrated that hydrocarbons that are ingested by marine organisms pass through the wall of the gut and become part of their lipid pool. Within the body lipids even relatively unstable hydrocarbons are preserved. Natural hydrocarbons and hydrocarbons from pollution that have been incorporated into the lipids of marine organisms are protected from bacterial attack and can be transferred from food organisms to predators; thus, they spread throughout the marine food web in a manner similar to that of other persistent chemicals, e.g. DDT (Blumer, Souza and Sass, 1970; Blumer, 1967; Blumer et al 1969).

It appears that hydrocarbons within marine sediments are also well protected from bacterial degradation. Thus in a spill of fuel oil in West Falmouth, Massachusetts, U.S.A., oil was incorporated into the sediments of coastal waters, rivers, harbours and marshes. The oil has persisted within the sediments for many months after the accident in unchanged composition and toxicity and we find that transport of oil-laden sediments still is contaminating areas that were free from contamination for months after the accident (Blumer, Souza and Sass, 1970).

5 OIL - IMMEDIATE TOXICITY

All crude oils and all oil fractions except highly purified and pure materials are poisonous to all marine organisms. This is not a new finding. The wreck of the TAMPICO in Baja California, Mexico (1957) "created a situation where a completely natural area was almost totally destroyed suddenly on a large scale..... Among the dead species were lobsters, abalone, sea urchins, starfish, mussels, clams and hosts of smaller forms" (North, 1967). Similarly, the spill of fuel oil in West Falmouth, Massachusetts, U.S.A., has virtually extinguished life in a productive coastal and intertidal area, with a complete kill extending over all phyla represented in that habitat (Hampson and Sanders, 1969 and unpublished data). Toxicity is immediate and leads to death within minutes or hours (Wilber, 1969).

These complex fractions are principally responsible for this immediate toxicity. The low boiling saturated hydrocarbons have, until recently, been considered harmless to the marine environment. But this fraction, which is readily soluble in sea water, produces at low concentration anaesthesia and narcosis and at greater concentration cell damage and death in a wide variety of lower animals; it may be especially damaging to the young forms of marine life (Goldacre, 1968). The low boiling aromatic hydrocarbons are the most immediately toxic fraction. Benzene, toluene and xylene are acute poisons for man as well as for other organisms; naphthalene and phenanthrene are even more toxic to fishes than benzene, toluene and xylene (Wilber, 1969). These hydrocarbons and substituted one-, two- and three-ring hydrocarbons of similar toxicity are abundant in all oils and most, especially the lower-boiling, oil products. Low-boiling aromatics are even more water soluble than the saturates and can kill marine organisms either by direct contact or through contact with dilute solutions. Olefinic hydrocarbons, intermediate in structure and properties and probably in toxicity between saturated and aromatic hydrocarbons, are absent in crude oil but occur in refining products, e.g. gasoline and cracked products, and are in part responsible for their immediate toxicity.

Numerous other components of crude oils are toxic, among those named by Speers and Whitehead (1969), cresols, xylenols, naphthols, quinoline and substituted quinolines and pyridines and hydroxybenzoquinolines are of special concern here because of their great toxicity and their solubility in water.

It is unfortunate that statements which disclaim this established toxicity are still being circulated. Simpson (1968) claimed that "there is no evidence that oil spilt round the British Isles have ever killed any of these (mussels, cockles, winkles, oysters, shrimps, lobsters, crabs) shellfish." It was obvious when this statement was made that such animals were indeed killed by the accident of the TORREY CANYON as well as by earlier accidents; work since then has confirmed the earlier investigation. In addition, by its emphasis on the adult life forms only, such a statement implies wrongly that juvenile forms also were unaffected.

6 OIL AND CANCER

The higher boiling crude oil fractions are rich in multiring aromatic compounds. It was at one time thought that only a few of these compounds, mainly 3, 4-benzopyrene, were capable of inducing cancer. As R.A. Dean (1968) of the British Petroleum Company stated "no 3, 4-benzopyrene has been detected in any crude oil...it therefore seems that the risk to the health of a member of the public by spillage of oil at sea is probably far less than that which he normally encounters by eating the foods he enjoys." However, already at the time when this statement was made, carcinogenic fractions containing 1,2-benzanthracene and alkylbenzanthracenes had been isolated by Carruthers, Stewart and Watkins (1967) and it was known that "biological tests have shown that the extracts obtained from high-boiling fractions of the Kuwait oil.....(method).....are carcinogenic." Further "Benzanthracene derivatives, however, are evidently not the only type of carcinogen in the oil....."

We now know that a far wider range of polynuclear aromatic compounds than benzopyrene and benzanthracene are potent tumor initiators. A wide range of alkylated 4-and 5-ring aromatic hydrocarbons have such carcinogenic activity (Wynder and Hoffman, 1968) and it is relevant that alkyl substituted polycyclic aromatic hydrocarbons predominate in the aromatic fraction from crude oils (Meinschein, 1969). According to Wilber (1969) "there is evidence that even a highly refined diesel engine lubricating oil obtained from a naphthenic base crude oil, and lacking in substances ordinarily known to be carcinogenic, can induce tumors of the digestive tract of animals." Also, "Cutting oil is known to have carcinogenic potency".

These references and a general knowledge of the composition of crude oils suggest that all crude oils and all oil products containing hydrocarbons boiling between 300 and 500°C should be viewed as potential cancer inducers.

This has severe implications for fisheries and human health. In our study of the West Falmouth oil spill (Blumer, Souza and Sass, 1970) we have shown that oil from a spill is taken up by shellfish and built into their body fat without fractionation of the hydrocarbons. In that specific accident an oil boiling between about 170 and 370°C was involved; this boiling range overlaps with that within which carcinogens have to be expected. Human consumption of such contaminated shellfish and other fisheries resources should therefore be viewed with great suspicion.

Carcinogenic hydrocarbons can enter the chain leading to human food at an even lower level; thus, it was shown by Doerr (1965) that intact plant roots can take up carcinogens like 3, 4-benzopyrene from their growth medium.

Other questions suggest themselves: Floating masses of crude oil now cover all oceans and are being washed up on shores. It has been thought that such stranded lumps "are of little consequence ecologically" (Spooner, 1969). We have shown that such lumps, even after considerable weathering, still contain nearly the full range of hydrocarbons of the original crude oil, extending in boiling point as low as 150°C. Thus such lumps still contain some of the immediately toxic lower boiling hydrocarbons and could hardly be considered ecologically of little consequence. In addition, the oil lumps contain all of the potentially carcinogenic material in the 300-500° boiling fraction. The presence of oil lumps ("tar") or finely dispersed oil on recreational beaches may well constitute a severe public health hazard, through continued skin contact.

7 OIL - DESTRUCTION OF FISHERIES RESOURCES

It has been said that "a review of the literature indicates that in deep water, whether in the open ocean or a mile or so offshore, no significant damage to marine life is encountered from even large oil spills because pelagic fish avoid the spill and few other marine species are present" (Little, 1969). We wonder whether anyone could take such a statement seriously, who knows the established toxicity of crude oil, the richness of coastal life and the complexity of marine life cycles. The dead fish of many different species that were washed ashore after the West Falmouth oil spill (Hampson and Sanders, 1969), clearly were unable to avoid the spill, nor will the fish fry in estuaries and marshes or the planktonic food organisms in the open ocean be able to avoid a large spill or the plume of toxic dissolved hydrocarbons descending from it. Unfortunately, investigation of the effects of major accidents (e.g. TORREY CANYON, Santa Barbara) have very largely concentrated on the study of damage to adult fish or of any immediate reduction in fish catches. This is not sufficient, we must also consider the damage to the often more delicate juvenile forms and to the food organisms on which commercial fishes feed. Damage to these will not show up immediately nor will it be evident necessarily at the location of the accident. A large spill may lead to a gradual reduction of productivity over a large but diffusely defined area. The combined effect of many such spills and of other stresses, e.g. from overfishing and from the filling of marshlands, may lead to a reduction in fishing income which is difficult to trace to any single cause.

The so-called "tainting" of fish and shellfish by oil spills has been recognized for many years; however, it was not realized until now that oil does not "pass through the gut without harm"(Spooner, 1969) but is incorporated into and stabilized in the lipid pool of the organisms (Blumer, Souza and Sass, 1970).

It is widely assumed that fish and shellfish "tainted" by oil will again be fit for human consumption after a period from 2 weeks (Simpson, 1968) to several months (Little, 1969). Our experience makes this highly improbable. For one thing, natural hydrocarbons, e.g. pristane which also occurs in crude oil, are retained in the lipids of marine organisms for life (Blumer, 1967; Hampson and Sanders, 1969). Further, shellfish exposed to the West Falmouth oil spill had retained the fuel oil to which they had been exposed several months after the accident (Blumer, Souza and Sass, 1970). If the oil were contained solely in the gut of the animals, it might be readily displaced; however, oil is resorbed and incorporated into the lipids where it may not be readily mobilized as long as the animal lives.

The disappearance of an "oily smell" is no clue whether fish or shellfish has cleansed itself of the oil pollution. Only a small fraction of the petroleum has a pronounced odor and loss of these compounds may occur while the more harmful high-boiling, taste-and odorless carcinogens are retained. It has been reported that boiling or frying will remove the odor; however, it will not affect the presence of polycyclic aromatic hydrocarbons.

8 OIL - LOW LEVEL EFFECTS

We are concerned that oil pollution, even at very low levels, may be responsible for long-term damage to the marine ecology. Many biological processes, which are important for the survival of marine organisms and which occupy key positions in their life processes, are mediated by extremely low concentration of chemical messengers in the sea water. We have demonstrated that marine predators are attracted to their prey by organic compounds at concentrations near the part per billion level (Whittle and Blumer, 1970). Such chemical attraction - and in a similar way repulsion - plays a role in the finding of food, the escape from predators, in homing of many commercially important species of fishes, in the selection of habitats and in sex attraction. There is good reason to believe that pollution interferes with these processes in two ways: by blocking the taste receptors and by mimicking for natural stimuli; the latter leads to false responses. Those crude oil fractions likely to interfere with such processes are high boiling saturated and aromatic hydrocarbons and the full range of the olefinic hydrocarbons.

It has long been known that lobsters are attracted to crude oil distillate fractions, especially kerosene (Prudden, 1967; Anon 1969); this has now been confirmed in the laboratory and with purified hydrocarbon fractions derived from kerosene (Boylan, 1969). Thus it is likely that an oil spill will attract lobsters away from their normal food and guide them into the direction of the spill, where they are more likely to be severely contaminated or killed. Again, this is in direct contradiction to the opinion quoted above (Little, 1969) that marine animals will actively avoid oil spills. It may be relevant that after the West Falmouth oil spill numerous dead lobsters were washed ashore.

Interference with an animal's normal sense of smell and taste by pollutants at very low and seemingly innocuous concentration levels may have disastrous effects on the survival of any marine species and the damage may extend to other species to which it is tied by the marine food web.

9 COUNTERMEASURES

Compared to the number and size of accidents and disasters, the present countermeasures are inadequate. However, a rapidly advancing technology is hopeful of developing techniques that will be effective in dealing even with very large spills under severe sea conditions. Yet, while we may remain hopeful that the gross esthetic damage from oil spills may be avoided sometime in the future, there is no reason to be hopeful that existing or planned countermeasures will reduce the biological impact of oil pollution.

The most immediately toxic fractions of oil and oil products are soluble in sea water; therefore, biological damage will occur at the very moment of the accident. Water currents will immediately spread the toxic plume of dissolved oil components and, if the accident occurs in inshore waters, the whole water column will be poisoned even if the bulk of the oil floats on the surface. The speed with which the oil dissolves is increased by agitation, and in storm conditions the oil will partly emulsify and will present a much larger surface area to the water; consequently, the toxic fraction will dissolve more rapidly and reach higher concentrations.

From the point of view of avoiding the immediate biological effect of oil spills, countermeasures are completely effective only if all of the oil is recovered immediately after the spill. The technology to achieve this goal does not exist. Some comments on existing countermeasures and their biological effects appear appropriate:

9.1 Detergents and dispersants

The toxic, solvent-based detergents which did so much damage in the clean-up after the TORREY CANYON accident are presently only in limited use. However, so-called "nontoxic dispersants" have been developed. The term "nontoxic" is misleading; these chemicals may be nontoxic to a limited number of often quite resistant test organisms but they are rarely tested in their effects upon a very wide spectrum of marine organisms including their juvenile forms, preferably in their normal habitat. Further, in actual use the dispersant-oil mixtures are severely toxic, and bacterial degradation of "nontoxic" detergents may lead to toxic breakdown products.

The effect of a dispersant is to lower the surface tension of the oil to a point where it will disperse in the form of small droplets. It is recommended that the breakup of the oil slick be aided by agitation, natural or mechanical. Thus, the purpose of the detergent is essentially a cosmetic one and it is therefore attractive to a polluter, who is concerned about his public image or potential lawsuits resulting from obvious esthetic damage. However, the recommendation to apply dispersants ("the use of newer dispersants of low toxicity is desirable here (in estuaries and salt marshes) and on shores" (Spooner, 1969) is made in complete disregard of their ecological effects. Instead of removing the oil, dispersants push the oil actively into the marine environment; because of the finer degree of dispersion, the immediately toxic fraction dissolves rapidly and reaches a higher concentration in the sea water than it would if natural dispersal were allowed. The long-term poisons (e.g. the carcinogens) are made available to and are ingested by marine filter feeders, and they can eventually return to man incorporated into the food he recovers from the ocean.

For these reasons I feel that the use of dispersants is unacceptable, inshore or offshore, except under special circumstances, e.g. extreme fire hazard from spillage of gasoline.

9.2 Physical sinking

Sinking has been recommended: "The long-term effects on marine life will not be as disastrous as previously envisaged. Sinking of oil may result in the mobile bottom dwellers moving to new locations for several years; however, conditions may return to normal as the oil decays" (Little, 1969). Again, these conclusions disregard our present knowledge of the effect of oil spills.

Sunken oil will kill the bottom fauna rapidly, before most mobile bottom dwellers have time to move away. The sessile forms of commercial importance (oysters, scallops, etc.) will be killed and other mobile organisms (lobsters) may be attracted into the direction of the spill where the exposure will contaminate or kill them. The persistent fraction of the oil which is not readily attacked by bacteria contains the long-term poisons, e.g. the carcinogens, and they will remain on the sea bottom for very long time periods. Exposure to these compounds may damage organisms or render them unfit for human nutrition even after the area has been repopulated.

9.3 Combustion

Burning the oil through the addition of wicks or oxidants appears more attractive from the point of view of avoiding biological damage than dispersion and sinking. However, it will be effective only if burning can start immediately after a spill. The elevated temperature of the oil during burning will increase the water solubility of the most toxic components of the oil; this may lead to greater biological damage than if the same amount of oil had been mechanically recovered.

9.4 Mechanical containment and removal

Containment and removal appear ideal from the point of avoiding biological damage. However, they can be effective only if applied immediately after the accident. Under severe weather conditions, floating booms and barriers are ineffective. Booms were applied during the West Falmouth oil spill; however, the biological damage in the sealed-off harbours was severe and was caused probably by the oil which bypassed the booms in solution in sea water and in the form of wind-dispersed droplets.

9.5 Biological degradation

Hydrocarbons in the sea are naturally degraded by marine micro-organisms. It is hoped to make this the basis of an oil removal technology through bacterial seeding and fertilization of oil slicks. However, great obstacles and many unknowns stand in the way of the application of this attractive idea.

No single microbial species will degrade any whole crude oil; bacteria are highly selective and complete degradation requires many different bacterial species (ZoBell, 1969). Bacterial oxidation of hydrocarbons produces many intermediates which may be more toxic than the hydrocarbons; therefore, organisms are also required that will further attack the hydrocarbon decomposition products (ZoBell, 1969).

Hydrocarbons and other compounds in crude oil may be bacteriostatic or bacteriocidal (ZoBell, 1969); this may reduce the rate of degradation, where it is most urgently needed. The fraction of crude oil that is most readily attacked by bacteria is the least toxic one, the normal paraffins; the toxic aromatic hydrocarbons, especially the carcinogenic polynuclear aromatics, are not rapidly attacked (Blumer, Souza and Sass, 1970; ZoBell, 1969).

The oxygen requirement in bacterial oil degradation is severe; the complete oxidation of 1 gal of crude oil requires all the dissolved oxygen in 320,000 gal of air-saturated sea water (ZoBell, 1969). Therefore, oxidation may be slow in areas where the oxygen content has been lowered by previous pollution and the bacterial degradation may cause additional ecological damage through oxygen depletion.

9.6 Cost effectiveness

The high value of fisheries resources, which exceeds that of the oil recovery from the sea, and the importance of marine proteins for human nutrition demand that cost effectiveness analysis of oil spill countermeasures consider the cost of direct and indirect ecological damage. It is disappointing that existing studies completely neglect to consider these real values (Little, 1969). A similarly one-sided approach would be, for instance, a demand by fisheries concerns that all marine oil production and shipping be terminated, since it clearly interferes with fisheries interests.

We have to start to realize that we are paying for the damage to the environment, especially if the damage is as tangible as that of oil pollution to fisheries resources and to recreation. Experience has shown that cleaning up a polluted aquatic environment is much more expensive than it would have been to keep the environment clean from the beginning (Ketchum, 1970). In terms of minimizing the environmental damage, spill prevention will produce far greater returns than cleanup - and we believe that this relationship will hold in a realistic analysis of the overall cost effectiveness of prevention or cleanup costs.

10 SELFCONTROL AND LAW ENFORCEMENT

The oil industry has an outstanding personnel and plant safety record. Oil refineries probably operate more safely than any other plants of equal production capacity. The industry has achieved this record through internal control because of the realization of the cost effectiveness of personnel safety.

We believe that the oil industry at the present is not aware of the substantiated toxicity of oil in the marine environment. If the oil industry recognizes the threat that oil pollution poses to our best use of the marine resources, it may well strive for an ecological safety record similar to its plant safety record.

It would be unrealistic to expect that intentional and negligent oil pollution can be stopped through education or appeals to man's responsibility. In this respect law enforcement will have to speak more strongly. Methods for the identification of oil spills by day and night through spectroscopic surveys from airplanes are becoming available (Swaby, 1969). Active tagging of oil in marine transit (Horowitz, 1969) should provide for simple and conclusive identification of spills. Even without active tagging, which depends on the willing cooperation of the ship owners and operators, each oil and oil product has its unique fingerprint. Sophisticated analytical techniques are available (e.g. capillary gas chromatography combined with mass spectrometry) that can qualitatively and quantitatively determine hundreds of different compounds in a spilled oil within a very short time. These techniques are available and simple and should be a great aid to more effective law enforcement.

In their effectiveness for law enforcement these techniques could be greatly supported if the oil industry would make available samples or analyses of those crude oils and products which are being transported across the sea.

11 CONCLUSIONS

The toxicity of crude oil and oil products to marine life and the danger of oil pollution to the marine ecology has been established in several independent ways:

1. Studies of crude oil composition and isolation of compounds known to be toxic, e.g. low boiling aromatic hydrocarbons and the carcinogenic, high boiling polycyclic aromatics
2. Laboratory studies of the effect of oil and oil fractions on marine organisms
3. Field studies of the effect of oil spills on marine organisms in their normal habitat

Pollution with crude oil and oil fractions <u>damages the marine ecology</u> through different effects:

1. Direct kill of organisms through coating and asphyxiation (Arthur, 1968)
2. Direct kill through contact poisoning of organisms
3. Direct kill through exposure to the water-soluble toxic components of oil at some distance in space and time from the accident
4. Destruction of the generally more sensitive juvenile forms of organisms
5. Destruction of the food sources of higher species
6. Incorporation of sublethal amounts of oil and oil products into organisms resulting in reduced resistance to infection and other stresses (the principal cause of death in birds surviving the immediate exposure to oil; Beer, 1968).

7. Destruction of food values through the incorporation of oil and oil products into fisheries resources

8. Incorporation of carcinogens into the marine food chain and human food sources

9. Low level effects that may interrupt any of the numerous events necessary for the propagation of marine species and for the survival of those species which stand higher in the marine food web

Some distillates may be more poisonous than some crude oils - thus, kerosene and #2 fuel oil are particularly rich in the low boiling water-soluble poisons and higher boiling distillates are rich in carcinogenic hydrocarbons. However, the toxicity of oil is spread over such a wide boiling range, and the composition of different crudes in terms of their chemical type distribution is so similar, that all crude oils and distillates must be considered severe environmental poisons.

Crude oil and most products are persistent poisons; they enter the marine food chain, they are stabilized in the lipids of marine organisms and they are transferred from prey to predator. The persistence is especially severe for the most poisonous compounds of oil; most of these do not normally occur in organisms and natural pathways for their biodegradation are missing.

Because of their low density, relative to sea water, crude oil and distillates should float; however, both the experiences of the TORREY CANYON and of the West Falmouth oil spill have shown oil on the sea floor. Oil in inshore and offshore sediments is not readily biodegraded; it can move with the sediments and can contaminate unpolluted areas long after an accident.

None of the presently used containment and recovery techniques prevents the ecological damage and the damage to fisheries products from oil spills. Toxicity is evident immediately and the poisonous fraction will be carried in water solution away from the accident, even if the surface spill is contained and recovered rapidly. Detergents and dispersants, while cosmetically effective, are especially harmful since they introduce all the oil into the environment. There are no dispersants that are not toxic in the presence of oil. The use of dispersants should be most strongly discouraged.

Natural mechanisms for the degradation of oil in the sea exist; unfortunately, these are least effective for the most severely toxic components of oil. As a result, the most toxic fractions are also the most persistent ones. The breakdown products of oil and dispersants may also be toxic. Further, oil that has been incorporated into the lipids of marine organisms and into the sediments at the sea bottom and in estuaries and marshes is largely unavailable to the natural degradation; poisoning of the bottom habitats and of the marine food web will therefore be more severe and more persistent than the poisoning of the water column itself.

The tolerance of the marine ecology to oil spills is unknown. The great persistence of oil and the existence of low level effects suggest a lower tolerance than we would expect by considering only the immediate toxicity of oil at high concentration levels.

The effects of oil pollution, especially in the coastal environment, cannot be considered without also considering the other stresses on these most productive regions of the ocean.

The combined impact of oil and oil products, chemicals, domestic sewage and municipal wastes, of the filling of wetlands, of dredging and of overfishing might lead to a deterioration of the coastal regions similar to that which we have brought about in the Great Lakes. Because of the much longer time scale of the oceans, such a catastrophic deterioration would not likely be reversed within many generations; it would have a deep and lasting impact on the future of mankind.

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SCIENTIFIC ASPECTS OF THE OIL SPILL PROBLEM

BY

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SCIENTIFIC ASPECTS OF THE OIL SPILL PROBLEM

*By Max Blumer**

The Extent of Marine Oil Pollution

Oil pollution is the almost inevitable consequence of our dependence on an oil-based technology. The use of a natural resource without losses is nearly impossible and environmental pollution occurs through intentional disposal or through inadvertent losses in production, transportation, refining and use. How large is the oil influx to the ocean? The washing of cargo tanks at sea, according to the director of Shell International, Marine Ltd.[1] had the potential in 1967 of introducing 2.8 million tons into the ocean, assuming that no use was made of the Load on Top (LOT) technique. With the increase in ocean oil transport from 1967 to 1970 this potential has grown to 6 million tons. The LOT technique is not being applied to one quarter of the oil tonnage moved by tankers; consequently, these vessels introduce about 1.5 million tons of oil into the sea. The limitations of the LOT technique have been described by E. S. Dillon[2]: the technique is not always used even if the equipment exists, the equipment may be inadequate, shore receiving facilities may be lacking and principal limitations lie in the formation of emulsions in heavy seas or with heavy crude oils. Insufficient time may be available for the separation of the emulsion or the oil water interface may not be readily recognized. In addition the most toxic components of oil are also readily soluble in water and their disposal into the ocean could be avoided only if clean ballasting were substituted for the LOT technique. For these reasons it is estimated that the present practices in tanker ballasting introduce about 3 million tons of petroleum into the ocean. The pumping of bilges by vessels other than tankers contributes another 500,000 tons.[3] In addition, in-port losses from collisions and during loading and unloading contribute an estimated 1 million tons.[4]

Oil enters the ocean from many other sources whose magnitude is much less readily assessed. Among these are accidents on the high seas (Torrey Canyon) or near shore, outside of harbors (West Falmouth, Mass.), losses during exploration (oil based drilling mud) and production (Santa Barbara, Gulf of Mexico), in storage (submarine storage tanks) and in pipeline breaks, and spent marine lubricants and incompletely burned fuels. A major contribution may come from untreated domestic and industrial wastes; it is estimated that nearly 2 million tons of used lubricating oil is unaccounted for each year in the United States alone, and, a significant portion of this reaches our coastal waters.[5,6]

Thus, the total annual oil influx to the ocean lies probably between 5 and 10 million tons. A more accurate assessment of the oil pollution of the oceans and of the relative contribution of different oils to the different marine environments is urgently needed. Such an assessment might well lie within the role of the NATO Committee on Challenges of the Modern Society.

With the anticipated increase in foreign and domestic oil production, with increased oil transport and with the shift of production to more hazardous regions (Alaska, continental shelf, deep ocean), we can expect a rapid increase of the spillage rate and of the oil influx to the ocean. Floating masses of crude oil ("tar") are now commonly encountered on the oceans and crude oil is present on most beaches. Oil occurs in the stomach of surface feeding fishes[7] and finely dispersed hydrocarbons occur in marine plants (e.g. sargassum[8]) and in the fat of fish and shellfish.[6,9a] Hydrocarbons from a relatively small and restricted oil spill in the coastal waters of Massachusetts, U.S.A., have spread, nine months after the accident to an area occupying 5000 acres (20 km^2) offshore and 500 acres (2 km^2) in tidal rivers and marshes. The effect on the natural populations in this area has been catastrophic. The full extent of the coverage of the ocean bottom by petroleum hydrocarbons is unknown; chemical analyses are scarce or non-existent.

Evaluation of the Threat

Oil: Immediate Toxicity

All crude oils and all oil fractions except highly purified and pure materials are poisonous to all marine organisms. This is not a new finding. The wreck of the "Tampico" in Baja, California, Mexico (1957) "created a situation where a completely natural area was almost totally destroyed suddenly on a large scale. . . . Among the dead species were lobsters, abalone, sea urchins, starfish, mussels, clams and hosts of smaller forms."[10] Similarly, the spill of fuel oil in West Falmouth, Massachusetts, U.S.A., has virtually extinguished life in a productive coastal and intertidal area, with a complete kill extending over all phyla represented in that habitat (Hampson and Sanders[11] and unpublished data). Toxicity is immediate and leads to death within minutes or hours.[12]

Principally responsible for this immediate toxicity are three complex fractions. The *low boiling saturated hydrocarbons* have, until quite recently, been considered harmless to the marine environment. It has now been found that this fraction, which is rather readily soluble in sea water, produces at low concentration anaesthesia and narcosis and at greater concentration cell damage and death in a wide variety of lower animals; it may be especially damaging to the young forms of marine life.[13] The *low boiling aromatic hydrocarbons* are the most immediately toxic fraction. Benzene, toluene and xylene are acute poisons for man as well as for other organisms; naphthalene and phenanthrene are even more toxic to fishes than benzene, toluene and xylene.[14] These hydrocarbons and substituted one-, two-, and three-ring hydrocarbons of similar toxicity are abundant in all oils and most, especially the lower boiling, oil products. Low boiling aromatics are even more water soluble than the saturates and can kill marine organisms either by direct contact or through contact with dilute solutions. *Olefinic hydrocarbons*, intermediate in structure and properties, and probably in toxicity, between saturated and aromatic hydrocarbons are absent in crude oil but occur in refining products (*e.g.*, gasoline and cracked products) and are in part responsible for their immediate toxicity.

Numerous other components of crude oils are toxic. Among those named by Speers and Whitehead,[15] cresols, xylenols, naphthols, quinoline and substituted quinolines and pyridines and hydroxybenzoquinolines are of special concern here because of their great toxicity and their solubility in water. It is unfortunate that statements which disclaim this established toxicity are still being circulated. Simpson[16] claimed that "there is no evidence that oil spilt round the British Isles has ever killed any of these (mussels, cockles, winkles, oysters, shrimps, lobsters, crabs) shellfish." It was obvious when this statement was made that such animals were indeed killed by the accident of the Torrey Canyon as well as by earlier accidents; work since then has confirmed the earlier investigation. In addition, this statement, by its emphasis only on the adult life forms, implies wrongly that juvenile forms were also unaffected.

Oil and Cancer

The higher boiling crude oil fractions are rich in multiring aromatic compounds. It was at one time thought that only a few of these compounds, mainly 3,4-benzopyrene, were capable of inducing cancer. As R. A. Dean[17] of British Petroleum Company stated, "no 3,4-benzopyrene has been detected in any crude oil . . . [I]t therefore seems that the risk to the health of a member of the public by spillage of oil at sea is probably far less than that which he normally encounters by eating the foods he enjoys." However, at the time this statement was made, carcinogenic fractions containing 1,2-benzanthracene and alkylbenzanthracenes had already been isolated by Carruthers, Stewart and Watkins[18] and it was known that "biological tests have shown that the extracts obtained from high-boiling fractions of the Kuwait oil . . . (method) . . . are carcinogenic." Further, "Benzanthracene derivatives, however, are evidently not the only type of carcinogen in the oil. . . ." In 1968, the year when Dean claimed the absence of the powerful carcinogen 3,4 benzopyrene in crude oil, this hydrocarbon was isolated in crude oil from Libya, Venezuela and the Persian Gulf.[19] The amounts measured were between 450 and 1800 milligrams per ton of the crude oil.

Thus, we know that chemicals responsible for cancer in animals and man occur in petroleum. The causation of cancer in man by crude oil and oil products was observed some years ago, when a high incidence of skin cancer in some refinery personnel was observed. The cause was traced to prolonged skin contact by these persons with petroleum and with refinery products. Better plant design and education, aimed at preventing the contact, have since reduced or eliminated this hazard.[20] However, these incidents have demonstrated that oil and oil products can cause cancer in man, and have supported the conclusions based on the finding of known carcinogens in oil. These references and a general knowledge of the composition of crude oils suggest that all crude oils and all oil products containing high boiling aromatic hydrocarbons should be viewed as potential cancer inducers.

Safeguards in plant operations protect the public from this hazard. However, when oil is spilled into the environment we loose control over it and should again be concerned about the possible public health hazard from cancer-causing chemicals in the oil. We have shown that marine organisms ingest and retain hydrocarbons to which they are exposed. These are transferred to and retained by predators. In this way even animals that were not directly exposed to a spill can become polluted by eating contaminated chemicals. This has severe implications for commercial fisheries and for human health. It suggests that marketing and eating of oil contaminated fish and shellfish at the very least increases the body burden of carcinogenic chemicals and may constitute a public health hazard.

Other questions suggest themselves: Floating masses of crude oil now cover all oceans and are being washed up on shores. It has been thought that such stranded lumps are of little consequence ecologically. It has been shown that such lumps, even after considerable weathering, still contain nearly the full range of hydrocarbons of the original crude oil, extending in boiling point as low as 100°C. Thus such lumps still contain some of the immediately toxic lower boiling hydrocarbons. In addition, the oil lumps contain all of the potentially carcinogenic material in the 300–500° boiling fraction. The presence of oil lumps ("tar") or finely dispersed oil on recreational beaches may well constitute a severe public health hazard, through continued skin contact.

Low Level Effects of Oil Pollution

The short-term toxicity of crude oil and of oil products and their carcinogenic properties are fairly well understood. In contrast to this we are rather ignorant about the long term and low level effects of oil pollution. These may well be far more serious and long lasting than the more obvious short term effects. Let us look at low level interference of oil pollution with the marine ecology.

Many biological processes which are important for the survival of marine organisms and which occupy key positions in their life processes are mediated by extremely low concentration of chemical messengers in the sea water. We have demonstrated that marine predators are attracted to their prey by organic compounds at concentrations below the part per billion level.[21] Such chemical attraction—and in a similar way repulsion—plays a role in the finding of food, the escape from predators, in homing of many commercially important species of fishes, in the selection of habitats and in sex attraction. There is good reason to believe that pollution interferes with these processes in two ways, by blocking the taste receptors and by mimicking for natural stimuli. The latter leads to false response. Those crude oil fractions likely to interfere with such processes are the high boiling saturated and aromatic hydrocarbons and the full range of the olefinic hydrocarbons. It is obvious that a very simple—and seemingly innocuous—interference at extremely low concentration levels may have a disastrous effect on the survival of any marine species and on many other species to which it is tied by the marine food chain.

Research in this critical area is urgently needed. The experience with DDT has shown that low level effects are unpredictable and may suddenly become an ecological threat of unanticipated magnitude.

The Persistence of Oil in the Environment

Hydrocarbons are among the most persistent organic chemicals in the marine environment. It has been demonstrated that hydrocarbons are transferred from prey to predator and that they may be retained in organisms for long time periods, if not for life. Thus, a coastal spill near Cape Cod, Massachusetts, U.S.A., has led to the pollution of shellfish by fuel oil. Transplanting of the shellfish to clean water does not remove the hydrocarbons from the tissues. Oil may contaminate organisms not only at the time of the spill; hydrocarbon-loaded sediments continue to be a source of pollution for many months after the accident.

Oil, though lighter than water, does not remain at the sea surface alone; storms, or the uptake of organisms or minerals, sink the oil. Oil at the sea bottom has been found after the accidents of the Torrey Canyon at Santa Barbara and near Cape Cod. Clay minerals with adsorbed organic matter are an excellent adsorbent for hydrocarbons; they retain oil and may transport it to areas distant from the primary spill. Thus, ten months after the accident at Cape Cod, the pollution of the bottom sediments covers an area that is much larger than that immediately after the spill.

In sediments, especially if they are anaerobic, oil is stable for long time periods. Indeed, it is a key fact of organic geochemistry that hydrocarbons in anaerobic recent sediments survive for millions of years until they eventually contribute to the formation of petroleum.

Countermeasures

Compared to the number and size of accidents and disasters the present countermeasures are inadequate. Thus, in spite of considerable improvement in skimming efficiency since the Santa Barbara accident, only 10% of the oil spilled from the Chevron well in the Gulf of Mexico was recovered.[22] From an ecological point of view this gain is nearly meaningless. While we may remain hopeful that the gross esthetic damage from oil spills may be avoided in the future, there is no reason to be hopeful that existing or planned countermeasures will eliminate the biological impact of oil pollution.

The most immediately toxic fractions of oil and oil products are soluble in sea water; therefore, biological damage will occur at the very moment of the accident. Water currents will immediately spread the toxic plume of dissolved oil components and, if the accident occurs in inshore waters, the whole water column will be poisoned even if the bulk of the oil floats on the surface. The speed with which the oil dissolves is increased by agitation, and in storms the oil will partly emulsify and will then present a much larger surface area to the water; consequently, the toxic fractions dissolve more rapidly and reach higher concentrations. From the point of view of avoiding the immediate biological effect of oil spills, countermeasures are completely effective only if *all of the oil is recovered immediately* after the spill. *The technology to achieve this goal does not exist.*

Oil spills damage many coastal and marine values: water fowl, fisheries, and recreational resources; they lead to increased erosion; they diminish the water quality and may threaten human life or property through fire hazard. A judicious choice has to be made in each case: which—if any—of the existing but imperfect countermeasures to apply to minimize the overall damage or the damage to the most valuable resources. Guidelines for the use of countermeasures, especially of chemical countermeasures, exist[23] and are being improved.[24] Some comments on the ecological effects and desirability of the existing countermeasures appear appropriate.

Detergents and Dispersants

The toxic, solvent-based detergents which did so much damage in the clean-up after the Torrey Canyon accident are presently only in limited use. However, so-called "nontoxic dispersants" have been developed. The term "nontoxic" is misleading; these chemicals may be nontoxic to a limited number of often quite resistant test organisms but they are rarely tested in their effects upon a very wide spectrum of marine organisms including their juvenile forms, preferably in their normal habitat. Further, in actual use all dispersant-oil mixtures are severely toxic, because of the inherent toxicity of the oil, and bacterial degradation of "nontoxic" detergents may lead to toxic breakdown products.

The effect of a dispersant is to lower the surface tension of the oil to a point where it will disperse in the form of small droplets. It is recommended that the breakup of the oil slick be aided by agitation, natural or mechanical. Thus, the purpose of the detergent is essentially a cosmetic one. However, the recommendation to apply dispersants is often made in disregard of their ecological effects. Instead of removing the oil, dispersants push the oil actively into the marine environment; because of the finer degree of dispersion, the immediately toxic fraction dissolves rapidly and reaches a higher concentration in the sea water than it would if natural dispersal were allowed. The long term poisons (e.g. the carcinogens) are made available to and are ingested by marine filter feeders, and they can eventually return to man incorporated into the food he recovers from the ocean.

For these reasons I feel that the use of dispersants is unacceptable, inshore or offshore, except under special circumstances, *e.g.*, extreme fire hazard from spillage of gasoline, as outlined in the Contingency Plan for Oil Spills, Federal Water Quality Administration, 1969.[23,24]

Physical Sinking

Sinking has been recommended. "The long term effects on marine life will not be as disastrous as previously envisaged. Sinking of oil may result in the mobile bottom dwellers moving to new locations for several years; however, conditions may return to normal as the oil decays."[25] Again, these conclusions disregard our present knowledge of the effect of oil spills.

Sunken oil will kill the bottom faunas rapidly, before most mobile dwellers have time to move away. The sessile forms of commercial importance (oysters, scallops, etc.) will be killed and other mobile organisms (lobsters) may be attracted into the direction of the spill where the exposure will contaminate or kill them. The persistent fraction of the oil which is not readily attacked by bacteria contains the long term poisons, *e.g.*, the carcinogens, and they will remain on the sea bottom for very long periods of time. Exposure to these compounds may damage organisms or render them unfit for human nutrition even after the area has been repopulated.

The bacterial degradation of sunken oil requires much oxygen. As a result, sediments loaded with oil become anaerobic and bacterial degradation and reworking of the sediments by aerobic benthic organisms is arrested. It is one of the key principles of organic geochemistry that hydrocarbons in anaerobic sediments persist for million of years. Similarly, sunken oil will remain; it will slow down the resettlement of the polluted area; and it may constitute a source for the pollution of the water column and of fisheries resources for a long time after the original accident.

For these reasons I believe that sinking of oil is unacceptable in the productive coastal and offshore regions. Before we apply this technique to the deep ocean with its limited oxygen supply and its fragile faunas we should gather more information about the interplay of the deep marine life with the commercial species of shallower waters.

Combustion

Burning the oil through the addition of wicks or oxidants appears more attractive from the point of view of avoiding biological damage than dispersion and sinking. However, it will be effective only if burning can start immediately after a spill. For complete combustion, the entire spill must be covered by the combustion promoters, since burning will not extend to the untreated areas; in practice, in stormy conditions, this may be impossible to achieve.

Mechanical Containment and Removal

Containment and removal appear ideal from the point of avoiding biological damage. However, they can be effective only if applied immediately after the accident. Under severe weather conditions floating booms and barriers are ineffective. Booms were applied during the West Falmouth oil spill; however, the biological damage in the sealed-off harbors was severe and was caused probably by the oil which bypassed the booms in solution in sea water and in the form of wind-dispersed droplets.

Bacterial Degradation

Hydrocarbons in the sea are naturally degraded by marine microorganisms. Many hope to make this the basis of an oil removal technology through bacterial seeding and fertilization of oil slicks. However, great obstacles and many unknowns stand in the way of the application of this attractive idea.

No single microbial species will degrade any whole crude oil; bacteria are highly selective and complete degradation requires many different bacterial species. Bacterial oxidation of hydrocarbons produces many intermediates which may be more toxic than the hydrocarbons; therefore, organisms are also required that will further attack the hydrocarbon decomposition products.

Hydrocarbons and other compounds in crude oil may be bacteriostatic or bacteriocidal; this may reduce the rate of degradation, where it is most urgently needed. The fraction of crude oil that is most readily attacked by bacteria is the least toxic one, the normal paraffins; the toxic aromatic hydrocarbons, especially the carcinogenic polynuclear aromatics, are not rapidly attacked.

The oxygen requirement in bacterial oil degradation is severe; the complete oxidation of 1 gallon of crude oil requires all the dissolved oxygen in 320,000 gallons of air saturated sea water. Therefore, oxidation may be slow in areas where the oxygen content has been lowered by previous pollution and the bacterial degradation may cause additional ecological damage through oxygen depletion.

Cost Effectiveness

The high value of fisheries resources, which exceeds that of the oil recovery from the sea, and the importance of marine proteins for human nutrition demand that cost effectiveness analysis of oil spill countermeasures consider the cost of direct and indirect ecological damage. It is disappointing that existing studies completely neglect to consider these real values.[17] A similarly one-sided approach would be, for instance, a demand by fisheries concerns that all marine oil production and shipping be terminated, since it clearly interferes with fisheries interests.

We must start to realize that we are paying for the damage to the environment, especially if the damage is as tangible as that of oil pollution to fisheries resources and to recreation. Experience has shown that cleaning up a polluted aquatic environment is much more expensive than it would have been to keep the environment clean from the beginning.[26] In terms of minimizing the environmental damage, spill prevention will produce far greater returns than cleanup—and we believe that this relationship will hold in a *realistic* analysis of the overall cost effectiveness of prevention or cleanup costs.

The Risk of Marine Oil Pollution

The Risk to Marine Life

Our knowledge of crude oil composition and of the effects of petroleum on marine organisms in the laboratory and in the marine environment force the conclusion that petroleum and petroleum products are toxic to most or all marine organisms. Petroleum hydrocarbons are persistent poisons. They enter the marine food chain, they are stabilized in the lipids of marine organisms and they are transferred from prey to predator. The persistence is especially severe for the most poisonous compounds of oil; most of these do not normally occur in organisms and natural pathways for their biodegradation are missing.

Pollution with crude oil and oil fractions *damages the marine ecology* through different effects:

1. Direct kill of organisms through coating and asphyxiation.[27]
2. Direct kill through contact poisoning of organisms.
3. Direct kill through exposure to the water soluble toxic components of oil at some distance in space and time from the accident.
4. Destruction of the generally more sensitive juvenile forms of organisms.
5. Destruction of the food sources of higher species.
6. Incorporation of sublethal amounts of oil and oil products into organisms resulting in reduced resistance to infection and other stresses (the principal cause of death in birds surviving the immediate exposure to oil[28]).
7. Incorporation of carcinogenic and potentially mutagenic chemicals into marine organisms.
8. Low level effects that may interrupt any of the numerous events necessary for the propagation of marine species and for

the survival of those species which stand higher in the marine food web.

The degree of toxicity of oil to marine organisms and the mode of action are fairly well understood. On the other hand, we are still far from understanding the effect of the existing and increasing oil pollution on the marine ecology on a large, especially world wide, scale.

Few, if any, comprehensive studies of the effects of oil spills on the marine ecology have been undertaken. Petroleum and petroleum products are toxic *chemicals*; the long term biological effect of oil and its persistence cannot be studied without chemical analyses. Unfortunately, chemical analysis has not been used to support such studies in the past and conclusions on the persistence of oil in the environment have been arrived at solely by visual inspection. This is not sufficient; a sediment can be uninhabitable to marine bottom organisms because of the presence of finely divided oil, but the oil may not be visually evident. Marine foods may be polluted by petroleum and may be hazardous to man but neither taste nor visual observation may disclose the presence of the toxic hydrocarbons.

A coordinated biological and chemical study of the long-term effect and fate of a coastal oil spill in West Falmouth, Massachusetts, U.S.A. has shown that even a relatively low boiling, soluble and volatile oil persists and damages the ecology for many months after the spill. In this instance about 650 tons of #2 fuel oil were accidentally discharged into the coastal waters off the Massachusetts coast. I wish to summarize our present findings of the effect of this accident.

Persistence and Spread of the Pollution[9a,b]

Oil from the accident has been incorporated into the sediments of the tidal rivers and marshes and into the offshore sediments, down to 42 feet, the greatest water depth in the sea. The fuel oil is still present in inshore and offshore sediments, eight months after the accident. The pollution has been spreading on the sea bottom and now covers at least 5000 acres offshore and 500 acres of marshes and tidal rivers. This is a much larger area than that affected immediately after the accident. Bacterial degradation of the oil is slow; degradation is still negligible in the most heavily polluted areas and the more rapid degradation in outlying, less affected, areas has been reversed by the influx of less degraded oil from the more polluted regions. The kill of bottom plants and animals has reduced the stability of marshland and sea bottom; increased erosion results and may be responsible for the spread of the pollution along the sea bottom.

Bacterial degradation first attacks the least toxic hydrocarbons. The hydrocarbons remaining in the sediments are now more toxic on an equal weight basis than immediately after the spill. Oil has penetrated the marshes to a depth of at least 1–2 feet; bacterial degradation within the marsh sediment is still negligible eight months after the accident.

Biological Effects of the Pollution[11,12]

Where oil can be detected in the sediments there has been a kill of animals; in the most polluted areas the kill has been almost total. Control stations outside the area contain normal, healthy bottom faunas. The kill associated with the presence of oil is detected down to the maximum water depth in the area. A massive, immediate kill occurred offshore during the first few days after the accident. Affected were a wide range of fish, shellfish, worms, crabs and other crustaceans and invertebrates. Bottom living fishes and lobsters were killed and washed up on the beaches. Trawls in 10 feet of water showed 95% of the animals dead and many still dying. The bottom sediments contained many dead clams, crustaceans and snails. Fish, crabs, shellfish and invertebrates were killed in the tidal Wild Harbor River; and in the most heavily polluted locations of the river almost no animals have survived.

The affected areas have not been repopulated, nine months after the accident. Mussels that survived last year's spill as juveniles have developed almost no eggs and sperm.

Effect on Commercial Shellfish Values[9a,b]

Oil from the spill was incorporated into oysters, scallops, softshell clams and quahaugs. As a result, the area had to be closed to the taking of shellfish.

The 1970 crop of shellfish is as heavily contaminated as was last year's crop. Closure will have to be maintained at least through this second year and will have to be extended to areas more distant from the spill than last year. Oysters that were removed from the polluted area and that were maintained in clean water for as long as 6 months retained the oil without change in composition or quantity. Thus, once contaminated, shellfish cannot cleanse themselves of oil pollution.

The tidal Wild Harbor River, a productive shellfish area of about 22 acres, contains an estimated 4 tons of the fuel oil. This amount has destroyed the shellfish harvest for two years. The severe biological damage to the area and the slow rate of biodegradation of the oil suggest that the productivity will be ruined for a longer time.

Some have commented to us that the effects measured in the West Falmouth oil spill are not representative of those from a crude oil spill and that #2 fuel oil is more toxic than petroleum. However, the fuel oil is a typical refinery product that is involved in marine shipping and in many marine spillages; also, the fuel oil is a part of petroleum and as such it is contained within petroleum. Therefore, its effect is typical, both for unrefined oil and for refinery products. In terms of chemical composition crude oils span a wide range; many lighter crude oils have a composition very similar to those of the fuel oils and their toxicity and environmental danger corresponds respectively. However, many crude oils contain more of the persistent, long term poisons, including the carcinogens, than the fuel oils. Therefore, crude oils can be expected to have even more serious long term effects than the lower boiling fuel oils.

The pollution of fisheries resources in the West Falmouth oil spill is independent of the molecular size of the hydrocarbons; the oil taken up reflects exactly the boiling point distribution of the spilled oil. Thus, spills by other oils of different boiling point distributions can be expected to destroy fisheries resources in the same manner.

We believe that the environmental hazard of oil and oil products has been widely underestimated, because of the lack of thorough and extended investigations. The toxicity and persistence of the oil and the destruction of the fisheries resources observed in West Falmouth are typical for the effects of marine oil pollution.

The Risk to Human Use of Marine Resources

The destruction of marine organisms, of their habitats and food sources directly affects man and his intent to utilize marine proteins for the nutrition of an expanding population. However, the presence in oil of toxic and carcinogenic compounds combined with the persistence of hydrocarbons in the marine food chain poses an even more direct threat to human health. The magnitude of this problem is difficult to assess at this time. Our knowledge of the occurrence of carcinogens in oil is recent and their relative concentrations have been measured in very few oils. Also, our understanding of the fate of hydrocarbons, especially of carcinogens, in the marine food chain needs to be expanded.

Methods for the analysis of fisheries products for the presence of hazardous hydrocarbons exist and are relatively simple and the analyses are inexpensive. In spite of this no public laboratory in the United States—and probably in the world—can routinely perform such analysis for public health authorities. There is increasing evidence that fish and shellfish have been and are now being marketed which are hazardous from a public health point of view. Taste tests, which are commonly used to test for the presence of oil pollutants in fish or shellfish, are inconclusive. Only a small fraction of petroleum has a pronounced odor; this may be lost while the more harmful long term poisons are retained. Boiling or frying may remove the odor but will not eliminate the toxicity.

The Risk to the Recreational Use of Marine Resources

The presence of petroleum, petroleum products and petroleum residue ("tar," "beach tar") is now common on most recreational beaches. Toxic hydrocarbons contained in crude oil can pass through the barrier of the human skin and the prolonged skin contact with carcinogenic hydrocarbons constitutes a public health hazard. Intense solar radiation is known to be one of the contributing factors for skin cancer. The presence of carcinogens in beach tar may increase the risk to the public in a situation where a severe stress from solar radiation already exists.

The Risk to Water Utilization

Many of the toxic petroleum hydrocarbons are also water soluble. Water treatment plants, especially those using distillation, may transfer or concentrate the steam-volatile toxic hydrocarbons into the refined water streams, especially if dissolved hydrocarbons are present in the feed streams or if particulate oil finds its way into the plant intake.

Conclusions

1. Oil and oil products must be recognized as poisons that damage the marine ecology and that are dangerous to man. Fisheries resources are destroyed through direct kill of commercially valuable species, through sublethal damage and through the destruction of food sources. Fisheries products that are contaminated by oil must be considered as a public health hazard.

2. Only crude estimates exist of the extent of marine oil pollution. We need surveys that can assess the influx of petroleum and petroleum products into the ocean. They should be world-wide and special attention should be paid to the productive regions of the ocean; data are needed on the oil influx from tankers and non-tanker vessels, on losses in ports, on offshore and inshore accidents from shipping, exploration and production and on the influx of oil from domestic and industrial wastes.

3. The marine ecology is changing rapidly in many areas as a result of man's activities. We need to establish baseline information on composition and densities of marine faunas and floras and on the hydrocarbon levels and concentrations encountered in marine organisms, sediments and in the water masses.

4. All precautions must be taken to prevent oil spills. Prevention measures must be aimed at eliminating human error, at the present time the principal cause of oil spills.

5. Spill prevention must be backed by effective surveillance and law enforcement. *In terms of cost effectiveness spill prevention is far superior to cleanup.*

6. Perfection and further extension of the use of the Load on Top methods is promising as a first step in reduction of the oil pollution from tankers. The effectiveness of the technique should be more closely assessed and improvements are necessary in interface detection, separation and measurement of hydrocarbon content in the effluent, both in the dispersed and dissolved state. On a longer time scale, clean ballast techniques should supersede the Load on Top technique.

7. The impact of oil pollution on marine organisms and on sources of human food from the ocean has been underestimated because of the lack of coordinated chemical and biological investigations. Studies of the effect of oil spills on organisms in different geographic and climatic regions are needed. The persistence of hydrocarbon pollution in sea water, sediments and organisms should be studied.

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8. Research is urgently needed on the low-level and long term effects of oil pollution. Does oil pollution interfere with feeding and life processes at concentrations below those where effects are immediately measured? Are hydrocarbons concentrated in the marine food chain?

9. Carcinogens have been isolated from crude oil but additional efforts are needed to define further the concentrations and types of carcinogens in different crude oils and oil products.

10. The public health hazard from oil derived carcinogens must be studied. What are the levels of oil derived carcinogens ingested by man and how wide is the exposure of the population? How much does this increase the present body burden with carcinogens? Is there direct evidence for the causation of cancer in man by petroleum and petroleum products outside of oil refinery operations?

11. Public laboratories must be established for the analysis of fisheries products for toxic and carcinogenic chemicals derived from oil and oil products, and tolerance levels will have to be set.

12. The ocean has a limited tolerance for hydrocarbon pollution. The tolerance varies with the composition of the hydrocarbons and is different in different regions and in different ecological sub-systems. The tolerance of the water column may be greater than that of the sediments and of organisms. An assessment of this inherent tolerance is necessary to determine the maximum pollution load that can be imposed on the environment.

13. Countermeasures which remove the oil from the environment reduce the ecological impact and danger to fisheries resources. All efforts should be aimed at the most rapid and complete removal since the extent of the biological damage increases with extended exposure of the oil to sea water.

14. Countermeasures that introduce the entire, undegraded oil into the environment should be used only as a last resort in situations such as those outlined in the Contingency Plan of the Federal Water Quality Administration, involving extreme hazard to a major segment of a vulnerable species of waterfowl or to prevent hazard to life and limb or substantial hazard of fire to property. Even in those cases assessment of the long term ecological hazard must enter into the decision whether to use these countermeasures (detergents, dispersants, sinking agents).

15. As other countermeasures become more effective, the use

of detergents, dispersants and sinking agents should be further curtailed or abolished.

16. Efforts to intensify the natural bacterial degradation of oil in the environment appear promising and should be supported by basic research and development.

17. Ecological damage and damage to fisheries resources are direct consequences of oil spills. In the future, the cost of oil leases should include a fee for environmental protection.

18. Environmental protection funds derived from oil leases should be used to accomplish the necessary research and education in the oil pollution field.

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WOODS HOLE OCEANOGRAPHIC INSTITUTION,
Woods Hole, Mass., March 29, 1971.

DR. GARDNER S. HUNT,
Chemist, Maine Environmental Improvement Commission,
Augusta, Maine.

DEAR MR. HUNT: I wish to thank you for your recent visit and for the opportunity this has given me to discuss with you our research and recent publications on the environmental effects and fate of hydrocarbons.

In addition to our discussion I wish to submit to the Marine Environmental Improvement Commission the following comments on the report by Dr. Dale Straughan "Biological and Oceanographic Survey of the Santa Barbara Channel Oil Spill, 1969–1970", Vol. 1 and 2. My comments are concerned with the relation between that study and our own work and with the present hearing at Searsport, Maine.

Some press reviews have given the impression, that there is a principal and fundamental difference between Dr. Straughan's findings and those of the Woods Hole group. In fact, many of the findings complement each other. Where differences are apparent, this is in most cases due to the incompleteness of the Santa Barbara Study.

As you remember, the principal results of our study in the aftermath of the oil spill from the barge "Florida" at West Falmouth, Mass., on September 16, 1969 are:

The oil from the spill is persistent and remains in the sediments, now after 18 months past the accident.

The oil has spread and the polluted area is now much larger than immediately after the accident.

The oil spill had devastating effects on the marine life in the area. Where oil has been detected, there has been a kill of animals and in the most heavily polluted areas this kill was nearly complete.

The original faunas have not returned to the affected areas, 18 months after the accident, except in the most lightly polluted regions.

Oil from the spill was taken up by those shellfish that survived the accident. This has led the State and Town governments to close the shellfish areas to the public.

Before discussing some details concerning the Santa Barbara report I wish to make some principal comments:

Oil is a *chemical* that has severe *biological* effects; therefore oil pollution research to be fully meaningful must combine chemical with biological studies. For chemical characterization of the oil in sediments and organisms we use gas chromatography and mass spectrometry.

These techniques are widely used by the oil industry, in exploration for the characterization and correlation of oil in sediments and reservoirs, and in refining for analysis and quality control. These techniques describe the physical and chemical properties of an oil and their application is essential for the study of the environmental fate of petroleum.

It is one of the principal shortcomings of the Santa Barbara Study that no use has been made of these modern and conclusive techniques.

Crude oil contains many toxic hydrocarbons. From an oil analysis it is immediately evident which of these compounds, of known toxicity, are present.

The Santa Barbara report contains no analysis of the oil involved in the spill. How can we judge the effect of an environmental poison if we do not know its composition, its boiling range, the presence or absence of immediate or persistent poisons and of materials that constitute a hazard to human nutrition? Thus, the most important evidence by which one could judge the environmental hazard of the oil is missing.

The following comments refer to individual chapters of the Santa Barbara report.

Chapter 3 discusses measurements of the carbon fixation by algae in the Santa Barbara Region. This is measured during a three hour period. The results showed "no conclusive evidence of any major effect on phytoplankton attributed directly to the presence of oil in the environment".

It has been demonstrated elsewhere (O. G. Mironov, The Effect of Oil Pollution on Flora and Fauna of the Black Sea, paper presented at FAO Conference on Marine Pollution, Rome, December 1970) that petroleum concentrations as low as 0.01 ppm delay the cell division of algae and that higher concentrations (0.1–

1000 ppm) kill all cells. The Santa Barbara Investigation did not search for, and did not find, any such effects.

The inconclusive results of the short term carbon fixation experiments are the only data presented in the study by which the effect of the oil spill on the planktonic algae is to be judged.

Chapter 4 (Observations on the Zooplankton) contains no data relevant to the environmental effect of the Santa Barbara accident. "The scope of this paper is largely limited to a chronicle of the major constituents of the zooplankton". Thus, it is simply a review of the species occurring in the area, without comparing number, physical, chemical or biological state, before, during or after he spill.

It is recommended that a regular sampling program "could provide a basis for comparison, should another spill occur".

Elsewhere it has been shown that copepods ingest oil from an oil spill. As such, it becomes available to higher members of the food chain, including commercial fish species. No efforts are reported from Santa Barbara to verify this important point.

Chapter 5 (The Benthic Fauna) is the chapter from which we expected the most important information of the report.

In discussing his survey, the author states "the survey technique in itself may not be able to show elimination or reduction of sensitive and delicate organisms due to oil pollution, since this technique nearly automatically places the emphasis on common or large or otherwise obviously important organisms. A study of the smaller, lesser known organisms such as polychaetous annelids or amphipod crustaeceans might be of more value in estimating the effects of pollutants in the water than a survey of the large common organisms".

In our West Falmouth study, we find deep and lasting damage to the benthic fauna, specifically to the "smaller, lesser known organisms". These animals are important members of the bottom food chain and constitute a major source of fish food.

The author of chapter 5 states that his technique was not able to separate the effects of the oil spill from other factors and says "*This does not in any way or manner imply that the oil spill was without effects*". He notes a striking drop in the standing crop in areas where several wells have been drilled in recent years. He recommends a large scale program to monitor the benthos in considerable detail.

We emphasize that the results of such a monitoring program were available at West Falmouth, that the monitoring program continues and that it has led to the realization of the severity of the impact of oil on the bottom fauna.

Thus, the Santa Barbara Study leaves some of the most important questions unanswered.

Chapter 6 (Some Polychaetous Annelids) has no relation to the study of the effects of the accident at Santa Barbara. It is simply a classification of the annelid worms occurring in the area.

Again, many species of annelids were severely affected by the West Falmouth oil spill and information on the effect of the Santa Barbara accident on these animals would have been highly relevant.

Chapter 9 (A Study of the Bacterial Population) contains interesting information. It is shown that oil in the sediments at station 2 has persisted from the time of the accident to the termination of the report, *one and one half year after the accident*. Specifically, it is said: "Cores taken on March 31, May 1 and June 13 (1970), did not change in their oil content" and "The population of burrowing organisms did not appear again during the period of sampling".

This is in excellent agreement with the findings at West Falmouth. After the same length of time after the spill, we also find that the oil has persisted, that it is still toxic and that burrowing organisms have not reappeared.

A limited use has been made of gas chromatography in this chapter. The report "supports the suitability of this method for the determination of small quantities of hydrocarbons in marine bottom sediments" and suggest that "patterns may be observed in the presence or absence of certain peaks in the chromatogram from a particular crude oil even after a period of burial in the sediment".

This of course has long been common knowledge and is the reason why this technique is used so extensively by the oil industry and by our own investigation.

The chapter concludes by stating that further discussion "in this area of the study is *impossible without knowing the oil content of the individual sediment samples*".

I concur with this point and the extensive use of oil determination and analysis in the West Falmouth investigation demonstrates the successful use of these techniques to study the environmental fate of oil.

Chapter 10 (Breeding and Larval Settlement of Intertidal Invertebrates) demonstrates that "the presence of oil both from natural seepage and the January, 1969, spill apparently causes a reduction in reproduction in *Pollicipes polymerus* (a barnacle)." Similarly, the data indicate "that breeding in *Mytilus californianus* (a mussel) of Goleta Point was probably reduced after oil pollution". Also: "Larval settlement in all three species of barnacle was at least temporarily inhibited by oiling of substrates".

These findings of biological damage by oil pollution are then qualified by stating that "as long as only a small fraction of the entire population of these species is exposed to oil pollution, the species as a whole is not endangered by it".

Obviously, those concerned with maintaining productivity of a coastal environment worry as much about local kill or reduction in reproduction as about worldwide extinction of a species.

The chapter further states "The hypothesis has been advanced that organisms living in the Santa Barbara Channel are more resistant than normal to oil pollution, due to intermittent exposure to low doses from natural seeps. Data for *P. polymerus* and *M. californianus* indicate that even if they are better able to survive, their rate of reproduction is still lower in the presence of oil."

This is important in view of the common but unsupported statements that organisms in areas of natural seeps have adapted to the presence of oil.

In West Falmouth the intertidal invertebrates exposed to the oil have become polluted. As a result shellfish exploitation had to be halted to preclude a public health hazard. The Santa Barbara report lacks data in this regard; thus, we do not know whether shellfish that was polluted by the toxic oil has been consumed.

Chapter 11 (Oil Pollution and Fisheries) states "in summary, fish were still present in the Santa Barbara Channel following the January, 1969, oil spill." Also: "the reduction in fish catches in the Santa Barbara area was probably due to the problems of fishing in oily water rather than to the lack of fish".

Fishes, whose migratory history is largely unknown, are insensitive indicators of the effects of pollution. Also in West Falmouth "fish are still present"; however, their local food sources have been decimated. The oil has affected all classes of bottom animals, therefore we believe that fishes should be similarly affected though this may be less readily apparent because of the great mobility.

To a fisherman it must be rather irrelevant whether his catch has been reduced because of the lack of fish or because he cannot immerse his gear into the oily water. Both represent a loss of income due to oil pollution.

Again, no chemical analyses were carried out to test fish catches for the presence of oil from the blowout and to assess whether a public health hazard existed.

Chapters 12–16 deal with large marine mammals and birds, with which we have no experience in our area.

Hydrocarbon analyses are referred to in several instances (p. 261, p. 277 and p. 293). Data by which to judge the sensitivity and reliability of the technique are given only on p. 261. It is said that an analysis of lung tissue from a whale led to negative oil identification. "This method is sensitive in the 50–100 ppm level".

In our experience this is not a sufficient sensitivity. Polluted shellfish at West Falmouth contained as little as 4 ppm oil and only in two cases more than 50 ppm. Still, this was sufficient to cause biological damage and it led to condemnation of the shellfish beds by public health authorities.

Chapter 17 (The Rocky Intertidal) again discusses the effect of continuous oil seeps, such as at Coal oil point, on the coastal ecology. the text speaks of interference with the settlement of reproductive stages and the release of reproductive cells as well as reduction in photosynthesis and respiration. "It is likely that only organisms with the ability to evade effects of oil or with physiologically resistant means of reproduction and/or mature stages can survive to populate an area such as coal oil point."

One of the points of the summary is:

"The fauna and flora at coal oil point where oil is chronically present is composed of forms that may be oil tolerant and is composed of relatively few species, but the species that can survive the conditions of stress are there in large numbers."

The reduction in the number of species is typical of polluted areas. Some resistant species may proliferate; however, the elimination of the normal populations represents a severe ecological damage.

Again, these data disprove the assumption that organisms exposed to natural seeps develop an immunity to the oil. With the great persistence of the oil after a spill (now 1½ year, both at Santa Barbara and at West Falmouth) we have to face chronic pollution as the result of a single accident. There is little hope that the organisms will adapt to this, if they have not adapted to the even more permanent presence of oil at coal oil point.

Volume II presents a comprehensive physical and oceanographic survey of the Santa Barbara Channel. Most pertinent to our discussion is *Chapter 7* (Hydrocarbon Content). This chapter as well as the summary of Volume II and Chapter 9 of Volume I confirm and extend our findings on the environmental persistence of oil pollution.

Oil has persisted in the sediments during the entire period of the study, from January 1969 to June 1970. The hydrocarbons have been deposited at the sea bottom and Dr. Kolpack's interpretation of the mechanism responsible for this is identical to ours in the case of West Falmouth.

It is said that "resuspension and transportation of oil initially deposited in shallow water occurred and much of this material was subsequently deposited in deeper water". Elsewhere, the same author said that within four months after the accident the entire Santa Barbara basin was covered with oil from the spill. (R. L. Kolpack, FAO meeting on Marine Pollution, Rome, December 1970).

In analogy, we find that the oil at West Falmouth has spread within months of the accident to a far larger region. Wherever oil was detected a kill of the bottom faunas occurred.

The known toxicity of the oil spilled at Santa Barbara would suggest that a similar kill occurred. This would have been most readily apparent from a study of the smaller benthic organisms. However, such a complimentary study, which would have enhanced appreciably our understanding of the ecological damage at Santa Barbara, was not undertaken.

The general *Summary* (Chapter 18, Volume I) does not reflect the experimental limitations of the study or the caution expressed by some authors of individual chapters.

Thus, it is said that "there is no evidence of gross effects of oil pollution on plankton in the Santa Barbara Channel". I have outlined above how limited the observations on phytoplankton were and that no data relevant to damage by the oil is presented in the chapter on zooplankton. Thus, such a conclusion seems unwarranted.

The author of Chapter 5 is quite specific about the limitations of his technique, which "does not in any way or manner imply that the oil spill was without effect." The Summary does not reflect this caution and suggests that the striking drop in the standing crop in areas where wells have been drilled in recent years may be due to pollution effects from the increased human population in the area!

Chapter 9 contains relevant information on the persistence of the pollution. This is not reflected in the summary.

Chapter 10 mentions the reduction in reproductive rates of intertidal invertebrates. The summary says "as this species ranges from Alaska to Mexico, a reduction in breeding in a small selection of its range will not endanger the species as a whole." Obviously, this is correct but hardly relevant to the discussion of the ecological damage by the oil spill in the Santa Barbara area—or in other inshore areas, where oil spills may occur.

A few specific comments are necessary: "The presence of oil in the area may have resulted in normally high populations of oil degrading bacteria" (p. 412). No evidence for this is presented, in fact the persistence of oil discussed in Volume II and in Chapter 9 of Volume I suggests a slow rate of bacterial degradation since the oil is still present there, as it is at West Falmouth 1½ years after the spill.

"One hypothesis" explaining what is considered a small degree of ecological damage is "that the biota of the area had a high tolerance to oil built up by almost continuous exposure to small amounts of similar oil from natural seeps over long periods". This statement is diametrically opposed to the information given in chapters 10 and 17, Volume 1.

Regarding the toxicity of Santa Barabara crude oil it is said "this oil is relatively insoluble in water" (p. 412) and "crude oils from Santa Barbara and the Gulf of Mexico contain a lower percentage of aromatics" (meant is that the oil spilled at West Falmouth with 41% aromatics). No analytical support is offered for this statement. G. T. Philippi (Geochem. Acta, 1965, 29, 1021–1049) has published analyses of California crude oils. The aromatic content in the environmentally most stable fraction (boiling above 325° C) ranges from 50–60% in oils from the Los Angeles basin and between 45 and 49% in those from the Ventura basin—Any oil (including that from Santa Barbara, contains water soluble, toxic hydrocarbons.

It is stated that "as the oil floats at the surface of the water the volatile components are rapidly lost" and "the loss of volatile components reduces the potential toxicity of the oil". On p. 326 it is said, that "slicks remained at sea for several days before moving onto the beaches. This delay at sea allowed the oil to loose many of its toxic volatile components prior to its arrival on shore".—We have had an opportunity to analyze oil that arrived at the beaches of Santa Barbara after the spill in January 1969. In spite of the exposure at sea gas chromatography shows the presence of hydrocarbons boiling as low as n-dodecane. Mass spectrometry revealed the presence of benzenes (with 6 and more carbon atoms as substituents), of naphthalenes, tetralins and diphenyls (with 2 or more substituent carbons). The higher ring number aromatics that normally occur in crude oil are also present.

Thus, the hydrocarbons of the fuel oil range are still present in the "weathered" oil that arrived at the beach. The aromatics mentioned above are toxic as are the higher ring number compounds, some of them carcinogens. The oil has lost little of its acute, and probably none of its long term toxicity through the exposure at sea.

"A crude oil such as that found at Santa Barbara is far less toxic than a light refined crude oil" and "Evidence indicates that recovery is also more rapid after one of these crude oil spills than after a refined oil spill".—These statements are not supported by the text of the report. Even after weathering at sea the Santa Barbara oil has retained the toxic hydrocarbons of the fuel oil. With these compounds present in the oil, how can it then be "far less toxic"? I have mentioned the evidence for the environmental persistence of this oil. In fact, the presence of slowly degraded multiring aromatics in this oil, which are not present in the refined fuel oil, leads us to expect a much slower rate of biodegradation.

Returning to my original contention I note the agreement between this work and our own with regard to the persistence and the spread of oil pollution. It is significant that similar results are obtained in the case of two very different oils and under different physical and ecological circumstances. Thus, in this respect, the two investigations complement each other well.

I also note the agreement on the desirability to use gas chromotography to measure the presence of oil from a spill even after a period of burial in the sediments; even if almost no use has been made of this valuable tool at Santa Barbara.

The Santa Barbara study complements ours in finding further evidence for the biological dramage by oil, for instance the inhibition of reproduction in intertidal invertebrates and the prevention of the settling of their larvae.

The devastating effect of oil pollution and the destruction of fisheries resources which we witnessed at West Falmouth has not been noted by the investigators at Santa Barbara. This is not unexpected in view of the fact that the effect of the spill on the benthic organisms was not studied and that sensitive analyses for the hydrocarbons incorporated into fisheries resources were not used.

Thus, Dr. Straughan's final conclusion "that damage to the biota was not widespread" must be viewed in the light of the incompleteness of her data.

Your commission faces an important decision which may affect the long term future of one of our remaining unpolluted coastal regions. It could be a tragic mistake to take lightly those warnings which exist and to base a decision too heavily on findings that are not based on the full use of the best presently available methods and techniques.

Sincerely yours,

MAX BLUMER, *Senior Scientist.*

TESTIMONY OF MAX BLUMER, BEFORE THE SUBCOMMITTEE OF AIR AND WATER POLLUTION, SENATE COMMITTEE ON PUBLIC WORKS, MACHIAS, MAINE, JUNE 30, 1970

I am happy to appear before the Subcommittee on Air and Water Pollution to discuss the impact of oil port and refinery operations on the coastal ecology and on food derived from the area. I have been involved with the study of hydrocarbons in the sea and with the development of methods for their analysis for many years. An oil spill close to our laboratory last Fall has shown us how suitable these methods are for studying the fate of pollution in the environment and how much new information we can gain through the judicious application of such techniques.

This new information I wish to discuss. I will preface this with a review of the toxicity of oil in the environment. Later I will discuss the existing countermeasures to deal with oil spills and I will close by giving you my estimate of the effect of port and refinery operations on the ecology and fisheries in this area.

TOXICITY OF OIL AND OIL PRODUCTS

The toxicity of crude oil and oil products to marine life and the danger of oil pollution to the marine ecology has been established in several independent ways.

Studies of crude oil composition have shown that oil contains many known poisons, e.g. low boiling aromatic hydrocarbons, which are fact acting poisons and high boiling aromatic hydrocarbons, which act more slowly but are equally severe in their effect; some of them are known to cause cancer.

Laboratory studies on many marine animals have demonstrated the toxicity of oil and oil products.

Field studies have shown the disastrous effect of oil spills on marine organisms in their normal habitat.

From such investigations we know that all crude oils and all oil products, with the exception of some highly purified substances, are poisons for all marine organisms.

Pollution with crude oil and oil fractions can damage marine life in many different ways:

1. Direct kill of organisms through coating and asphyxiation.
2. Direct kill through contact poisoning of organisms.
3. Direct kill through exposure to the water-soluble toxic components of oil at some distance in space and time from the accident.
4. Destruction of the generally more sensitive juvenile forms of organisms.
5. Destruction of the food sources of higher species.
6. Incorporation of sublethal amounts of oil and oil products into organisms resulting in reduced resistance to infection and other stresses. Also, this may result in failure to reproduce.
7. Exposure to long-term poisons, e.g. carcinogens.
8. Low level effects that may interrupt any of the numerous events necessary for the feeding, migration and propagation of marine species and for the survival of those species which stand higher in the marine food web.

We need to comment on the problem of *Petroleum and Cancer*. Some years ago, a high incidence of skin cancer in some refinery personnel was observed. The cause was traced to prolonged skin contact by these persons with petroleum and with refinery products. Better plant design and education, aimed at preventing the skin contact, have since reduced or eliminated this hazard (Eckart, 1967). However, these incidents have demonstrated that oil and oil products can cause cancer in man, and these findings were supported by the isolation from petroleum of chemicals that are known to cause cancer and that were actually shown to induce cancer in test animals (Cook et al., 1958; Carruthers et al., 1967 Greaf and Winter, 1968.

Safeguards in plant operations protect the public from this hazard; however, when oil is spilled into the environment we loose control over it and should again be concerned about the possible public health hazard from cancer-causing chemicals in the oil. We have shown that marine organisms ingest and retain hydrocarbons to which they are exposed. These are transferred to and retained by predators. In this way even animals that were not directly exposed to a spill can become polluted by eating contaminated animals. This and the presence of cancer-causing chemicals in oil pollution implies that the marketing and eating of oil-contaminated fish and shellfish constitutes a public health hazard.

The presence of finely dispersed oil or oil lumps ("tar") on recreational beaches may constitute another public health hazard through prolonged skin contact, reinforcing the stress on the skin from the intense solar radiation.

THE OIL SPILL OF WEST FALMOUTH, MASSACHUSETTS

In September 1969 a fuel barge ruptured her hull on submerged rocks off West Falmouth. The cause for the accident was an error in navigation under conditions of good visibility. Approximately 650 tons of #2 fuel oil were discharged into the coastal waters. Chemists and biologists at Woods Hole are studying the immediate and long term effect of this spill.

The oil involved in this spill is typical of the refinery products that would be handled at Machiasport. It is a part of petroleum and as such it is contained within the crude oil that enters a refinery. Because of this, its effect is typical both for unrefined oil and for refinery products. However, certain fast-acting poisons are more concentrated in the fuel oil; on the other hand, whole crude oil contains much more of the persistent, long term poisons, including the carcinogens.

I wish to point out that this is the first study where modern methods of oil analysis have been coordinated with a biological study of the long term effect of an oil spill on the ecology and fisheries resources in a coastal area. It has been said that nine months after the Torrey Canyon accident "bottom samples revealed no trace of oil—microbial action and bottom currents had been fast and complete" (Eglinton, 1969). However, this conclusion rests only on visual observation. Visually oil is not evident at West Falmouth either; however, chemical analysis reveals its presence and the biological study measures its toxicity.

I now wish to summarize our present knowledge of the aftermath of this accident.

Persistence and spread of the pollution

Oil from the accident has been incorporated into the sediments of the tidal rivers and marshes and into the offshore sediments, down to 42 feet, the greatest water depth in this area.

The fuel oil is still present in inshore and offshore sediments, eight months after the accident.

The pollution has been spreading on the sea bottom and now covers at least 5000 acres offshore and 500 acres of marshes and tital rivers. This is a much larger area than that affected immediately after the accident.

Bacterial degradation of the oil is slow; degradation is still negligible in the most heavily polluted areas and the more rapid degradation in outlying, less affected, areas has been reversed by the influx of less degraded oil from the more polluted regions.

The kill of bottom plants and animals has reduced the stability of marshland and sea bottom; increased erosion results and may be responsible for the spread of the pollution along the sea bottom.

Bacterial degradation first attacks the least toxic hydrocarbons. The hydrocarbons remaining in the sediments are now more toxic on an equal weight basis than immediately after the spill.

Oil has penetrated the marshes to at least 1–2 feet depth; bacterial degradation within the marsh sediment is still negligible eight months after the accident.

(From: Blumer, Sass and Souza, 1970; Blumer, Sass and Souza, unpublished results.

Biological effects of the pollution

Where oil can be detected in the sediments there has been a kill of animals; in the most polluted areas the kill has been almost total. Control stations outside the area contain normal, healthy bottom faunas.

The kill associated with the presence of oil is detected down to the maximum water depth in the area.

A massive, immediate kill occurred offshore during the first few days after the accident. Affected were a wide range of fish, shellfish, worms, crabs and other crustaceans and invertebrates. Bottom living fishes and lobsters were killed and washed up on the beaches. Trawls in 10 feet of water showed 95% of the animals dead and many still dying. The bottom sediments contained many dead clams, crustaceans and snails.

Fish, crabs, shellfish and invertebrates were killed in the tidal Wild Harbor River; and in the most heavily polluted locations of the river almost no animals have survived.

The affected areas have not been repopulated, nine months after the accident.

Mussels that survived last year's spill as juveniles have developed almost no eggs and sperm.

(From: Hampson and Sanders, 1969; Sanders and Hampson, 1970; Sanders and Hampson, personal communication).

Effect on Commercial Shellfish Values

Oil from the spill was incorporated into oysters, scallops, softshell clams and quahaugs. As a result, the area had to be closed to the taking of shellfish.

The 1970 crop of shellfish is as heavily contaminated as was last year's crop. Closure will have to be maintained at least through this second year and will have to be extended to areas more distant from the spill than last year.

Oysters that were removed from the polluted area and that were maintained in clean water for as long as 6 months retained the oil without change in composition or quantity. Thus, once contaminated, shellfish cannot cleanse themselves of oil pollution.

The tidal Wild Harbor River, a productive shellfish area of about 22 acres, contains an estimated 4 tons of the fuel oil. This amount has destroyed the shellfish harvest for two years. The severe biological damage to the area and the slow rate of biodegradation of the oil suggest that the productivity will be ruined for a longer time.

The presence or absence of an "oily smell" is no clue for the presence of oil pollution in fish or shellfish. Only a small fraction of petroleum has a pronounced odor; this may be lost while the more harmful long-term poisons are retained. Boiling or frying may remove the odor but will not eliminate the toxicity.

(From: Blumer, Sass and Souza, 1970; Blumer, Sass and Souza, unpublished results).

COUNTERMEASURES

Compared to the number and size of accidents and disasters the present countermeasures are inadequate. However, a rapidly advancing technology is hopeful of developing techniques that will be effective in dealing even with large spills under severe sea conditions. Yet, while we may remain hopeful that the gross esthetic damage from oil spills may be avoided sometime in the future, there is no reason to be hopeful that existing or planned countermeasures will reduce the biological impact of oil pollution.

The most immediately toxic fractions of oil and oil products are soluble in sea water; therefore, biological damage will occur at the very moment of the accident. Water currents will immediately spread the toxic plume of dissolved oil components and, if the accident occurs in inshore waters, the whole water column will be poisoned even if the bulk of the oil floats on the surface. The speed with which the oil dissolves is increased by agitation, and in storm conditions the oil will partly emulsify and will present a much larger surface area to the water; consequently, the toxic fraction will dissolve more rapidly and reach higher concentrations.

From the point of view of avoiding the immediate and long-term biological effect of oil spills, *countermeasures are completely effective only if all of the oil is recovered immediately* after the spill. *The technology to achieve this goal does not exist.*

Detergents and Dispersants

The toxic detergents which were used in the Torrey Canyon accident have been replaced largely by so called "non-toxic" dispersants.

The term "non-toxic" is misleading; these chemicals may be nontoxic to a limited number of often quite resistant test organisms but they are rarely tested in their effects upon a very wide spectrum of marine organisms including their juvenile forms, preferably in their normal habitat. Further, in actual use the dispersant-oil mixtures are severally toxic, and bacterial degradation of "nontoxic" detergents may lead to toxic breakdown products. The purpose of the detergent is essentially a cosmetic one and it is therefore attractive to a polluter, who is concerned about his public image or potential lawsuits resulting from obvious esthetic damage. However, instead of removing the oil, dispersants push the oil actively into the marine environment; because of the finer degree of dispersion, the immediately toxic fraction dissolves rapidly and reaches a higher concentration in the sea water than it would if natural dispersal were allowed. The long-term poisons (e.g. the carcinogens) are made available to and are ingested by marine filter feeders, and they can eventually return to man incorporated into the food he recovers from the ocean.

For these reasons the use of dispersants is unacceptable, inshore or offshore, except under special circumstances, e.g. extreme fire hazard from spillage of gasoline.

Physical Sinking

Sinking has been recommended as an effective countermeasure. Sunken oil will kill the bottom faunas rapidly, before most mobile bottom dwellers have time to move away. The sessile forms of commercial importance (oysters, scallops, etc.) will be killed and other mobile organisms (lobsters) may be attracted into the direction of the spill where the exposure will contaminate or kill them.

Bacterial degradation of sunken oil is very slow and the persistent fraction of the oil which is not readily attacked by bacteria contains the long-term poisons, e.g. the carcinogens. Exposure to these compounds may damage organisms or render them unfit for human nutrition even after the area has been repopulated.

Combustion

Burning the oil through the addition of wicks or oxidants appears more attractive from the point of view of avoiding biological damage than dispersion and sinking. However, it will be effective only if burning can start immediately after a spill. The elevated temperature of the oil during burning will increase the water solubility of the most toxic components of the oil; this may lead to greater biological damage than if the same amount of oil had been mechanically recovered.

Mechanical Containment and Removal

Containment and removal appear idea from the point of avoiding biological damage. However, they can be effective only if applied immediately after the accident. Under severe weather conditions floating booms and barriers are ineffective. Booms were applied during the West Falmouth oil spill; however, the biological damage in the sealed-off harbors was and remains severe and was caused probably by the oil which bypassed the booms in solution in sea water and in the form of wind-dispersed droplets.

Biological Degradation

Hydrocarbons in the sea are naturally degraded by marine microorganisms. It is hoped to make this the basis of an oil removal technology through bacterial seeding and fertilization of oil slicks. However, great obstacles and many unknowns stand in the way of the application of this attractive idea.

No single microbial species will degrade any whole crude oil; bacteria are highly selective and complete degradation requires many different bacterial species. Bacterial oxidation of hydrocarbons produces many intermediates which may be more toxic than the hydrocarbons; therefore, organisms are also required that will further attack the hydrocarbon decomposition products.

Hydrocarbons and other compounds in crude oil may be bacteriostatic or bacteriocidal; this may reduce the rate of degradation, where it is most urgently needed. The fraction of crude oil that is most readily attacked by bacteria is the least toxic one, the normal paraffins; the toxic aromatic hydrocarbons, especially the carcinogenic polynuclear aromatics, are not rapidly attacked.

The oxygen requirement in bacterial oil degradation is severe; the complete oxidation of 1 gallon of crude oil requires all the dissolved oxygen in 320,000 gallons of air saturated sea water. Therefore, oxidation may be slow in areas where the oxygen content has been lowered by previous pollution and the bacterial degradation may cause additional ecological damage through oxygen depletion.

POLLUTION IN OIL PORTS

Four principal reasons have been given for pollution in oil ports (Dudley, 1968): Design faults, mechanical failure, spillage during loading or unloading and human error. Of these, the last is the most important cause of oil pollution and the most difficult one to correct. Most of the large accidents of recent years can be attributed to human error and poor judgment; among these are the accidents of the Torrey Canyon, at Santa Barbara, in the Gulf of Mexico and also the West Falmouth oil spill.

No oil port is able to avoid spillage. Severe measures have been taken to prevent or control oil pollution in Milford Haven, a large and modern British oil port, adjacent to a National Park. There, 29 million tons of oil were handled in 1966; of this, 2,900 tons were spilled in port. The largest single accident contributed more than 10% of this total and about one percent of the tankers entering port were involved in spillages, 15% of these were considerable (Dudley, 1968; Arthur, 1968).

Thus, in spite of modern technology and in spite of the declared intention to minimize pollution, 0.01% of the oil entering was lost in port. Other oil ports may have less favorable records, and a single large catastrophe in port could increase this spillage rate dramatically.

So far we have only considered losses from port operations. Additional pollution results from refinery operations. Separating plants remove the oil floating on top of water used in the plant or in the cleaning of tankers. However the toxic aromatic hydrocarbons are soluble in the water and are returned with it into the environment. According to Wilber (1969) refinery effluents, even after prolonged storage, do not lose their toxicity.

Good engineering practice can reduce the pollution from refineries but it cannot eliminate it and this pollution will present a stress on the environment in addition to that from the unavoidable pollution caused by the port operations.

THE EFFECT OF AN OIL PORT ON AN UNPOLLUTED ENVIRONMENT

I have described the ecological danger of oil, the persistence of oil pollution and the damage by oil to fisheries. We know that oil spills and discharges are inevitable in oil ports and refineries. It follows that port and refining operations must degrade the ecology and damage the fishing resources of an environment that is not now polluted by oil. Because of the persistence of oil and because of the ineffectiveness of countermeasures, the damage will be permanent.

How severe will this damage be? The capacity of the initial refinery may be 100,000 barrels per day. Assuming that spillage in port can be held at the exceptionally low level of 0.01%, as it is achieved in Millport Haven, and neglecting refinery effluents and possible large catastrophes, the average daily spillage will be 10 barrels or 1.5 tons. Thus, the amount spilled in two to three days would equal the amount of oil in Wild Harbor River, Massachusetts. There, this amount has destroyed the natural fauna of the estuary and ruined the shellfish crop for at least two years.

Over a full year, spillage at this rate would amount to 550 tons. As you remember, the West Falmouth oil spill amounted to about 650 tons and the pollution now covers at least 5,500 acres. In West Falmouth we hope that the spill will not soon repeat itself and that the environment will have a chance to recover; here, you would have a continuous influx, not permitting recovery, but increasing as the port and the refineries continue to grow.

I wish to comment on the impact of a possible large catastrophe in the Gulf of Maine, Fishing resources are not uniformly distributed over the ocean. One half of the world's fish catch comes from one tenth of one percent of the ocean surface. The Gulf of Maine is a prime example of one of the small but highly productive shallow water regions. A large oil spill in this area would pollute the sea bottom severely. This would destroy the food for commercial species of fish; it would contaminate even the fish not directly affected by the spill and fisheries products might have to be rejected from the market because of a public health hazard.

I conclude that the presence of an oil port and of refineries is incompatible with the maintenance of an unpolluted environment. I believe that the seriousness of oil pollution has been underestimated because of the lack of in-depth studies of its long term effect. I believe that the public health hazard of oil pollution is just now coming into focus and that more stringent limitations will have to be placed on the acceptability of polluted foods. I hope that this discussion will be considered in a final decision, whose effect will reach far beyond this area.

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He is a member of the American Chemical Society and of the American Association for the Advancement of Science. He has served on a FWPCA Panel on the Evaluation of the Toxicity of Detergents and a U.S. Coast Guard-National Academy of Sciences Panel on Pollution Monitoring.

Dr. Blumer is author of numerous scientific papers. His research interests and experience lie in the field of organic geochemistry, chemical oceanography and oil pollution. He has worked on the origin of petroleum, the chemical analysis of petroleum, the origin and the long term fate of organic compounds, especially hydrocarbons, in the sea and in the marine food chain.

Dr. Blumer acknowledges long term support of his work in these areas by the Office of Naval Research, by the National Science Foundation and by the Federal Water Quality Administration.

TESTIMONY OF MAX BLUMER, BEFORE THE CONSERVATION AND NATURAL RESORCES SUBCOMMITTEE, COMMITTEE ON GOVERNMENT OPERATIONS, WASHINGTON, D.C., JULY 22, 1970

I am happy to appear before the Subcommittee on Conservation and Natural Resources to discuss the environmental effects of increased oil traffic in the Potomac estuary. I have been involved with the study of hydrocarbons in the sea and with the development of methods for their analysis for many years. An oil spill close to our laboratory last Fall has shown us how suitable these methods are for studying the fate of pollution in the environment, and our analysis of the effect of this oil spill upon fisheries resources is directly applicable to the topic under discussion here.

THE OIL SPILL OF WEST FALMOUTH, MASS.

In September 1969 a fuel barge ruptured her hull on submerged rocks off West Falmouth. The cause for the accident was an error in navigation under conditions of good visibility. Approximately 650 tons of #2 fuel oil were discharged into the coastal waters. Chemists and biologists at Woods Hole are studying the immediate and long term effect of this spill. The oil involved in this spill is a refining product of petroleum. It is contained within the crude petroleum and as such it has effects which are typical both for unrefined oil and for refinery products. However, some differences exist in the mode of toxicity of different petroleum products. Thus, the lower boiling oil products, such as gasoline and kerosene, contain higher concentrations of many fast-acting poisons; on the other hand, the higher boiling oil fractions and whole crude oil contain much more of the persistent, long-term poisons, including substances known to produce cancer.

I wish to point out that this is the first study where modern methods of oil analysis have been coordinated with a biological study of the long term effect of an oil spill on the ecology and fisheries resources in a coastal area. It has been said that nine months after the Torrey Canyon accident "bottom samples revealed no trace of oil—microbial action and bottom currents had been fast and complete" (Eglinton, 1969). However, this conclusion rests only on visual observation. Visually oil is not evident at West Falmouth either; however, chemical analysis reveals its presence and the biological study measures its toxicity.

Now I wish to summarize our present knowledge of the aftermath of this accident.

Persistence and Spread of the Pollution

Oil from the accident has been incorporated into the sediments of the tidal rivers and marshes and into the offshore sediments, down to 42 feet, the greatest water depth in the sea.

The fuel oil is still present in inshore and offshore sediments, eight months after the accident.

The pollution has been spreading on the sea bottom and now covers at least 5000 acres offshore and 500 acres of marshes and tidal rivers. This is a much larger area than that affected immediately after the accident.

Bacterial degradation of the oil is slow; degradation is still negligible in the most heavily polluted areas and the more rapid degradation in outlying, less affected, areas has been reversed by the influx of less degraded oil from the more polluted regions.

The kill of bottom plants and animals has reduced the stability of marshland and sea bottom; increased erosion results and may be responsible for the spread of the pollution along the sea bottom.

Bacterial degradation first attacks the least toxic hydrocarbons. The hydrocarbons remaining in the sediments are now more toxic on an equal weight basis than immediately after the spill.

Oil has penetrated the marshes to at least 1–2 feet depth; bacterial degradation within the marsh sediment is still negligible eight months after the accident.

(From: Blumer, Sass and Souza, 1970; Blumer, Sass and Souza, unpublished results.)

Biological Effects of the Pollution

Where oil can be detected in the sediments there has been a kill of animals; in the most polluted areas the kill has been almost total. Control stations outside the area contain normal, healthy bottom faunas.

The kill associated with the presence of oil is detected down to the maximum water depth in the area.

A massive, immediate kill occurred offshore during the first few days after the accident. Affected were a wide range of fish, shellfish, worms, crabs and other crustaceans and invertebrates. Bottom living fishes and lobsters were killed and washed up on the beaches. Trawls in 10 feet of water showed 95% of the animals dead and many still dying. The bottom sediments contained many dead clams, crustaceans and snails.

Fish, crabs, shellfish and invertebrates were killed in the tidal Wild Harbor River; and in the most heavily polluted locations of the river almost no animals have survived.

The affected areas have not been repopulated, nine months after the accident.

Mussels that survived last year's spill as juveniles have developed almost no eggs and sperm.

(From: Hampson and Sanders, 1969; Sanders and Hampson, 1970; Sanders and Hampson, personal communication).

Effect on Commercial Shellfish Values

Oil from the spill was incorporated into oysters, scallops, soft-shell clams and quahaugs. As a result, the area had to be closed to the taking of shellfish.

The 1970 crop of shellfish is as heavily contaminated as was last year's crop. Closure will have to be maintained at least through this second year and will have to be extended to areas more distant from the spill than last year.

Oysters that were removed from the polluted area and that were mainained in clean waer for as long as 6 months retained the oil without change in composition or quantity. Thus, once contaminated, shellfish cannot cleanse themselves of oil pollution.

The tidal Wild Harbor River, a productive shellfish area of about 22 acres, contains an estimated 4 tons of the fuel oil. This amount has destroyed the shellfish harvest for two years. The severe biological damage to the area and the slow rate of biodegradation of the oil suggest that the productivity will be ruined for a longer time.

The presence or absence of an "oily smell" is no clue for the presence of oil pollution in fish or shellfish. Only a small fraction of petroleum has a pronounced odor; this may be lost while the most harmful long-term poisons are retained. Boiling or frying may remove the odor but will not eliminate the toxicity.

(From: Blumer, Sass and Souza, 1970; Blumer, Sass and Souza, unpublished results).

Toxicity of Oil and Oil Products

The toxicity of crude oil and oil products and the danger of oil pollution to the marine ecology and to public health has been established in several independent ways. Oil and oil products contain many known poisons, e.g. fast acting compounds like the low boiling aromatic hydrocarbons and slowly acting but equally severe poisons like the high boiling aromatic hydrocarbons.

Laboratory studies on many marine animals have demonstrated the toxicity of oil and oil products.

Field studies have shown the disastrous effect of oil spills on marine organisms in their normal habitat.

From such investigations we know that all crude oils and all oil products, with the exception of some highly purified substances, are poisons for all marine organisms. Oil pollution can harm marine resources in many different ways: through direct or indirect kill, through destruction of the sensitive juvenile forms and through the depletion of food resources. The incorporation of sublethal amounts of oil leads to reduced resistance to stress and may result in failure to reproduce. Low level effects, which are still poorly understood, may interrupt any of the numerous events necessary for the feeding, migration and propagation of marine species and for the survival of those species which stand higher in the marine food web.

We need to comment on the problem of *Petroleum and Cancer*. Some years ago, a high incidence of skin cancer in some refinery personnel was observed. The cause was traced to prolonged skin contact by these persons with petroleum and with refinery products (Eckart, 1967). These incidents have demonstrated that oil and oil products can cause cancer in man, and these findings were supported by the isolation from petroleum of chemicals that are known to cause cancer and that were actually shown to induce cancer in test animals (Cook et al., 1958; Carruthers et al., 1967; Greaf and Winter, 1968).

Safeguards in plant operations protect the public from this hazard; however, when oil is spilled into the environment, we lose control over it and should again be concerned about the possible public health hazard from cancer-causing chemicals in the oil. We have shown that marine organisms ingest and retain hydrocarbons to which they are exposed. These are transferred to and retained by predators. In this way even animals that were not directly exposed to a spill can become polluted by eating contaminated animals. This and the presence of cancer-causing chemicals in oil pollution implies that the marketing and eating of fish and shellfish from polluted areas may constitute a public health hazard.

THE INCIDENCE OF OIL SPILLS ; THE EFFECTIVENESS OF COUNTERMEASURES

No oil port is able to avoid spillage, and human error has been quoted as the principal casue of accidents (Dudley, 1968). It has been estimated that 0.01% of the oil entering port is lost, even in the most carefully managed ports (Dudley, 1968; Arthur, 1968; Blumer, 1969) ; in other ports the spillage may amount to 0.1% of the turnover. Ideally, countermeasures should be able to remove this spilled oil. However, the most severely toxic components of the oil are also water soluble, therefore biological damage will occur at the very moment of the accident. Countermeasures are fully effective only if *all* of the oil is recovered *immediately* after the spill. *The technology to achieve this goal does not exist.*

In spite of this, the use of containment and recovery techniques is to be encouraged; they will at least reduce the impact of the accident on the ecology. Burning may be called for under special circumstances, though damage will occur due to the partial dissolution of the oil under the burning oil layer.

However, I wish to advise strongly against the use of detergents, dispersants and sinking agents. These are purely cosmetic measures, which push the toxic oil actively into the environment with all the consequences of the kill of bottom organisms and destruction of fisheries resources through incorporation of oil.

RECOMMENDATIONS

1. Oil and oil products must be recognized as poisons that damage the marine ecology. They destroy fisheries resources through direct kill, through sublethal damage and through the destruction of food sources. Polluted fish and shellfish become a public health hazard.

2. All precautions should be taken to reduce the spillage; they should be aimed at eliminating human error. Records must be kept of all spills. Spill prevention must be backed by surveillance and law enforcement. A chemical laboratory must be available to establish the tie between a spill and a vessel or port facility. *In terms of cost effectiveness spill prevention is far superior to cleanup.*

3. Bacterial degradation eventually destroys spilled oil. Therefore, the environment has some limited tolerance for spills. Investigations like ours will establish the tolerance level; however, additional investigations involving other oil spills and other ecological circumstances are needed.

4. The spillage rate and the environmental tolerance determine directly how much oil a port can handle without causing additional environmental degradation.

5. Containment of the spills and recovery or burning at the earliest possible time are favored in spite of their shortcomings. The use of detergents, dispersants or sinking agents should not be permitted except in cases of extreme fire hazard.

6. Continuing chemical and biological surveys can establish the present extent and any further spread of the ecological deterioration. Chemical analysis is needed to establish the safety of fish and shellfish for human nutrition. Such surveys are possible; they are relatively inexpensive and high priority should be given to establish laboratories to perform these analyses on a continuing basis in all major port areas. There is a definite danger that fisheries products are now being marketed which are not acceptable from the point of view of public health.

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Dr. Blumer was born in Switzerland and received his education at the University of Basel, Switzerland (Ph.D. 1949). He became a U.S. citzen in 1964. He has been associated with industry (CIBA, Limited, and Shell Development Company) and with academic institutions (University of Minnesota, Scripps Institution of Oceanography). He has been at the Woods Hole Oceanographic Institution since 1959.

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TESTIMONY OF MAX BLUMER, BEFORE THE ANTITRUST AND MONOPOLY SUBCOMMITTEE, U.S. SENATE, WASHINGTON, D.C., AUGUST 4–6, 1970

CONCLUSIONS

A moderately large oil spill has occurred off the shores of Cape Cod in September 1969. In the first joint investigation of its kind biologists and chemists of the Woods Hole Oceanographic Institution are examining the damage done to the marine life and the persistence of the oil in the environment. Oil from this spill has killed a wide range of marine life. The pollution at the sea bottom is still spreading, ten months after the accident, and now covers at least 5,000 acres offshore and 500 acres of marshes and tidal rivers. The polluted area has not yet been repopulated. Shellfish that have survived the spill in the less contaminated areas have become polluted by the oil and are now a public health hazard. Therefore, large shellfish areas had to be closed in the Fall of 1969 and the area had to be extended further in 1970. Shellfish that have taken up oil cannot cleanse themselves, if they are transplanted into uncontaminated areas.

Petroleum and petroleum products are poisons for all marine organisms and for man. Petroleum contains many poisons, among them substances which cause cancer in animals and in man. Therefore, the presence of petroleum and of petroleum products in marine foods constitutes a public health hazard which should be taken seriously.

Existing countermeasures against oil spills differ in their effectiveness and desirability. Some are purely cosmetic measures (detergents, dispersants and sinking agents) that push the toxic oil into the environment and cause more harm than if the spill were left alone. Countermeasures are completely effective only if all the oil is recovered immediately after the spill. The technology to achieve this goal does not exist.

Oil spills of various types now introduce between 2 and 10 million tons of oil into the ocean every year. With increasing production and transport and with a shift of the production to more dangerous locations in the Arctic and on the Continental Shelves, spills will increase more rapidly than the oil production. This large influx of oil into the ocean causes severe damage. Only through recent investigations, like that of the oil spill in the Cape Cod area, have we become aware of the great hazard that oil constitutes to the marine ecology, to fisheries resources and to human health.

We urge that all precautions must be taken to prevent oil spills. In terms of cost effectiveness spill prevention is far superior to clean up. In offshore drilling conservation must be practiced. It must not be aimed, as in the past, only at utilizing the oil reserves in the best way. Conservation must now include the protection of the environment and the maintenance of our recreational and fisheries resources. In the granting of offshore leases consideration must be made of the ecological hazards and the danger to fisheries resources and human health. In future offshore leases a percentage of the revenue should be allocated for environmental protection. These funds should be used for a survey before and during production, for the funding and establishment of laboratories to carry out such surveys and for research on the effects of oil pollution on the marine ecology, on fisheries resources and on public health. These funds should support training and education in marine ecology and in the pollution field.

I am thankful for the invitation to appear before the Antitrust and Monopoly Subcommittee to discuss the risks inherent in expanded offshore drilling and oil transport. I have studied the fate of hydrocarbons in the sea and in marine organisms for many years. At the Woods Hole Oceanographic Institution with which I have been associated since 1959, my work centers on hydrocarbons in the marine food chain and on their effect upon marine organisms and man. A study of the aftermath of an oil spill close to our laboratory has shown us how little we knew about the effects of oil pollution on the marine ecology.

I wish to review our findings of the ecological and commercial damage caused by this oil spill. Later I will comment on the toxicity of oil in the environment and the present state of the art of countermeasures. I will conclude with a discussion of the world wide problem of oil pollution and with recommendations for environmental protection.

THE OIL SPILL OF WEST FALMOUTH, MASSACHUSETTS

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I wish to point out that this is the first study where modern methods of oil analysis have been coordinated with a biological study of the long-term effect of an oil spill on the ecology and fisheries resources in a coastal area. It has been said that nine months after the *Torrey Canyon* accident "bottom samples revealed no trace of oil—microbial action and bottom currents had been fast and complete" (Eglinton, 1969). However, this conclusion rests only on visual observation. Visually, oil is not evident at West Falmouth either; however, chemical analysis reveals its presence and the biological study measures its toxicity.

A massive, immediate kill occurred offshore during the first few days after the accident. Affected were a wide range of fish, shellfish, worms, crabs and other crustaceans and invertebrates. Bottom living fishes and lobsters were killed and washed up on the beaches. Trawls in 10 feet of water showed 95% of the animals dead and many still dying. The bottom sediments contained many dead clams, crustaceans and snails.

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Oil from the spill was incorporated into oysters, scallops, soft-shell clams and quahaugs. As a result, the area had to be closed to the taking of shellfish.

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Oysters that were removed from the polluted area and that were maintained in clean water for as long as 6 months retained the oil without change in composition or quantity. Thus, once contaminated, shellfish cannot cleanse themselves of oil pollution.

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TOXICITY OF OIL AND OIL PRODUCTS

The toxicity of crude oil and oil products and the danger of oil pollution to the marine ecology and to public health has been established in several independent ways. Oil and oil products contain many known poisons, e.g. fast acting compounds like the low boiling aromatic hydrocarbons and slowly acting but equally severe poisons like the high boiling aromatic hydrocarbons.

Laboratory studies on many marine animals have demonstrated the toxicity of oil and oil products.

Field studies have shown the disastrous effect of oil spills on marine organisms in their normal habitat.

From such investigations we know that all crude oils and all oil products, with the exception of some highly purified substances, are poisons for all marine organisms. Oil pollution can harm marine resources in many different ways: through direct or indirect kill, through destruction of the sensitive juvenile forms and through the depletion of food resources. The incorporation of sublethal amounts of oil leads to reduced resistance to stress and may result in failure to reproduce. Low level effects, which are still poorly understood, may interrupt any of the numerous events necessary for the feeding, migration and propagation of marine species and for the survival of those species which stand higher in the marine food web.

We need to comment on the problem of *Petroleum and Cancer*. Some years ago, a high incidence of skin cancer in some refinery personnel was observed. The cause was traced to prolonged skin contact by these persons with petroleum and with refinery products (Eckart, 1967). These incidents have demonstrated that oil and oil products can cause cancer in man, and these findings were supported by the isolation from petroleum of chemicals that are known to cause cancer and that were actually shown to induce cancer in test animals (Cook et al., 1968; Carruthers et al., 1967; Greaf and Winter, 1968).

Safeguards in plant operations protect the public from this hazard; however, when oil is spilled into the environment, we lose control over it and we should again be concerned about the possible public health hazard from cancer-causing chemicals in the oil. We have shown that marine organisms ingest and retain hydrocarbons to which they are exposed. These are transferred to and retained by predators. In this way even animals that were not directly exposed to a spill can become polluted by eating contaminated animals. This and the presence of cancer-causing chemicals in oil pollution implies that the marketing and eating of fish and shellfish from polluted areas may constitute a public health hazard.

The toxicity of petroleum does not depend on its source; thus, all oils are poisons regardless of the field where they were produced and regardless of whether they are spilled from a tanker, a shore facility or from a submarine well or pipeline.

COUNTERMEASURES

Compared to the number and size of accidents and disasters the present countermeasures are inadequate. However, a rapidly advancing technology is hopeful of developing techniques that will be effective in dealing even with large spills under severe sea conditions. Yet, while we may remain hopeful that the gross esthetic damage from oil spills may be avoided sometime in the future, there is no reason to be hopeful that existing or planned countermeasures will reduce the biological impact of oil pollution.

The most immediately toxic fractions of oil and oil products are soluble in sea water; therefore, biological damage will occur at the very moment of the accident. Water currents will immediately spread the toxic plume of dissolved oil components and, if the accident occurs in inshore waters, the whole water column will be poisoned even if the bulk of the oil floats on the surface. The speed with which the oil dissolves is increased by agitation, and in storm conditions the oil will partly emulsify and will present a much larger surface area to the water; consequently, the toxic fraction will dissolve more rapidly and reach higher concentrations.

From the point of view of avoiding the immediate and long-term biological effect of oil spills, *countermeasures are completely effective only if all of the oil is recovered immediately* after the spill. *The technology to achieve this goal does not exist.*

Existing countermeasures differ in their effectiveness and desirability. I wish *to advise strongly against the use of detergents, dispersants and sinking agents.* Instead of removing the oil these measures push the oil into the marine environment. It will kill organisms in the water or on the sea bottom, and animals that survive the immediate impact can be harmed by the long term poisons which are present in petroleum. Sunken or dispersed oil can be taken up by fish and will destroy their food value because of the presence of substances poisonous to man.

For these reasons I feel that the use of dispersants and sinking agents are unacceptable, inshore or offshore, except under special circumstances e.g. where danger to human life is involved.

Burning by such means as the addition of wicks or oxidents appears more attractive from the point of view of avoiding biological damage by dispersion and sinking. However, it will be effective only if burning can start immediately after a spill.

Containment and removal appear ideal from the point of avoiding biological damage. However, they can be effective only if applied immediately after the accident. Under severe weather conditions floating booms and barriers are ineffective. Booms were applied during the West Falmouth oil spill; however, the biological damage in the sealed-off harbors was severe and was caused probably by the oil which bypassed the booms in solution in seawater and in the form of wind-dispersed droplets.

THE PROBLEM OF WORLD WIDE OIL POLLUTION

Oil pollution is the most inevitable consequence of our dependence on an oil-based technology. The use of a natural resource without losses is nearly impossible and environmental pollution occurs through intentional disposal or through inadvertent losses in production, transportation, refining and use. Large catastrophes like that of the *Torrey Canyon*, the blowouts at Santa Barbara and in the Gulf of Mexico get the attention of the public because of the obvious esthetic damage and the harm to birds. Small and continuing spills and their far greater impact on less visible resources are less apparent to the public. It is estimated that annually 10,000 pollution incidents occur in waters and that oil pollution accounts for 7,500 of these. We have estimated that the total influx of oil to the ocean per year amounts now to between two and ten million metric tons. Technology continues to expand, the sea transport of oil will increase and production will shift to the more hazardous locations in the Arctic and on the Continental Shelves. Losses will increase therefore even more rapidly than the oil production.

We know that oil is poisonous to all marine life and to man. In our study of the West Falmouth oil spill we have demonstrated for the first time the very severe and lasting impact of a spill on the ecology and fisheries resources. There is no doubt now that the annual influx of 2–10 million tons of oil into the ocean causes severe damage.

It is difficult to assess at this time how large this damage is. With the exception of our work in West Falmouth, no large-scale and long-time studies have been undertaken in which the present resources of chemistry and biology have been applied to undestand the effect of oil spills. No public laboratory in this country is equipped at this time to determine whether fish or shellfish has become a hazard to human nutrition through the incorporation of toxic petroleum hydrocarbons.

The value of fisheries resources is still higher than that of the oil recovered from the sea. The importance of marine proteins for human nutrition demands that the damage to fisheries resources by oil pollution be considered in any cost analysis of marine oil production. It is disappointing that these real costs and values have been disregarded in all planning for the extension of marine oil production, oil transport and port design. A similarly one-sided approach would be, for instance, a demand by fisheries concerns that all marine oil production and shipping be terminated, since it clearly interferes with fisheries interests.

We have to start to realize that we are paying for the damage to the environment, especially if the damage is as tangible as that of oil pollution to fisheries resources and to recreation. Experience has shown that cleaning up a polluted aquatic environment is much more expensive than it would have been to keep the environment clean from the beginning. In terms of minimizing the environmental damage, spill prevention will produce far greater returns than cleanup.

Finally, I wish to point out that it is not sufficient to consider the effect of oil pollution without also considering the other stresses on the productive regions of the ocean.

The combined impact of oil and oil products, chemicals, domestic sewage and municipal wastes, of the filling of wetlands, of dredging and of overfishing might lead to a deterioration of the sea similar to that which we have brought about in the Great Lakes. Because of the much longer time scale of the oceans, such a catastrophic deterioration would not likely be reversed within many generations; it would have a deep and lasting impact on the future of mankind.

RECOMMENDATIONS

1. Oil and oil products must be recognized as poisons that damage the marine ecology. Fisheries resources are destroyed through direct kill, through sublethal damage and through the elimination of food sources. Oil is poisonous to man and polluted fisheries products are a public health hazard.

2. All precautions must be taken to prevent oil spills. Preventive measures must be aimed at eliminating human error, at the present the principal cause of oil spills.

3. Spill prevention must be backed by effective surveillance and law enforcement. *In terms of cost effectiveness spill prevention is far superior to cleanup.*

4. The conservation practiced in oil production has been aimed primarily at preserving the oil reserves in our oil reservoirs. Oil production, transportation and refining have largely disregarded the need to conserve the environment and to maintain our recreational and fisheries resources. Conservation must now be aimed at preserving the environment. Optimum use must be made of our oil reserves at minimum cost to the environment.

5. The hazard in offshore drilling increases with the number of wells being drilled, the number and length of pipelines, and the number and size of marine storage facilities. These paramenters should be minimized to reduce the environmental hazard.

6. In the granting of offshore leases consideration must be made of the ecological hazards and of the danger to fisheries resources.

7. Ecological damage and damage to fisheries resources is a direct consequence of oil spills. At the present time all of us are paying the direct and indirect cost of this damage. In future offshore leases a certain percentage of the revenue should be allocated for environmental protection.

8. Environmental protection funds derived from offshore oil leases should be used to accomplish these tasks:

(*a*) Ecological and chemical survey of the area before drilling is started.

(*b*) Ecological and chemical survey, continued during the period of production.

(*c*) Establishment and funding of laboratories to carry out continuous chemical and biological surveys.

(*d*) Research on the effects of oil pollution on the marine ecology, on fisheries resources and on public health.

(*e*) Research on realistic countermeasures that will recover spilled oil or render it harmless *in situ,* not measures that introduce the oil into the environment at undiminished toxicity.

(*f*) Training and education in marine ecology and in the pollution field.

9. Present federal funding in the area of marine pollution is insufficient and the granting process is cumbersome. Research funds have to be renegotiated annually with complete restatement of the goals. Proposal writing and frequent interim reporting require a large fraction of the time that should be devoted to the research. The funding level should be increased, research with long-term goals should be funded for three to five year terms and the administrative load on the investigator should be reduced at least to the level that now satisfies the National Science Foundation.

10. Oil and oil products in all forms are equally dangerous. Thus, whether the oil is derived from a well or from a tanker or from any other source does not affect its enviornmental toxicity. In drilling operations oil is commonly used as the base of drilling muds. When spilled or disposed into the ocean, an oil based-drilling mud will damage marine life and fisheries resources in the same manner as an oil spill. Therefore, oil-based drilling muds used at sea must be contained and their disposal must be prohibited.

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He is a member of the American Chemical Society and of the American Association for the Advancement of Science. He has served on a FWPCA Panel on the Evaluation of the Toxicity of Detergents and a U.S. Coast Guard—National Academy of Sciences Panel on Pollution Monitoring.

Dr. Blumer is author of numerous scientific papers. His research interests and experience lie in the field of organic geochemistry, chemical oceanography and oil pollution He has worked on the origin of petroleum, the chemical analysis of petroleum, the origin and the long term fate of organic compounds, especially hydrocarbons, in the sea and in the marine food chain.

Dr. Blumer acknowledges long term support of his work in these areas by the Office of Naval Research, by the National Science Foundation and by the Federal Water Quality Administration.

Persistence and Degradation of Spilled Fuel Oil

Abstract.—In September 1969, 600 tons of #2 fuel oil was spilled in Buzzards Bay, Massachusetts. Two years later, fuel oil hydrocarbons persist in the marsh and in offshore sediments. Hydrocarbon degradation is slow, especially below the immediate sediment surface and appears to proceed principally through microbial utilization of alkanes and through partial dissolution of the lower boiling aromatics. The boiling range of the spilled oil and the relative abundances of homologous hydrocarbons (e.g. phytane and pristane) have been well preserved.

The findings agree with the known geochemical stability of hydrocarbons. Fuel oil is an appreciable fraction of whole crude oil. This suggests that oil products and crude oils have a considerable environmental persistence. (Submitted to: Science, 1972.)

Oil pollution of the sea and the public awareness of it has increased rapidly in recent years. In spite of this, little information exists on the persistence and long-term effect of hydrocarbon pollutants in the marine environment.

The fate of fuel oil from a spill in Buzzards Bay off West Falmouth, Mass. USA, on September 16, 1969 has been under investigation for more than two years. The relatively small spill involved the discharge from a stranded barge of approximately 600 tons of #2 fuel oil into the coastal waters and marshes. It led to perisitent pollution of the sediments and of the fisheries resources (1–3).

Among the events that followed the 1969 spill we can distinguish three distinct, though partly overlapping series of events. Within the first few hours or days after the accident there was a heavy kill of organisms which came into contact with the oil; the effect extended over all phyla and over benthic and intertidal organisms (2, 4).

Next, within weeks or months after the spill the oil spread to areas that had not been affected initially and the kill extended, though in some cases more slowly than the spread of the oil, to outlying areas. For a considerable time after the spill, the oil prevented resettlement of the sediments by the original fauna. Now, degradation of the oil is evident; concurrently with the chemical changes in the oil, the immediate toxicity of the oil in the sediment has been reduced. This has permitted resettlement of the polluted region, first by the most resistant faunal opportunists and later by a more varied and normal fauna (4).

Our analyses show the slow decrease of the oil content of the sediments from the high initial values in the marshes (Wild Harbor River) and offshore (Station 31, Silver Beach Harbor, Fig. 1). At both locations the oil content has remained well above the level of the indigenous sedimentary hydrocarbons, which average 5–7 mg/100 g dry sediment. The steep increase in the oil content at Station 31 between December 1969, and March 1970, is attributed to the redistribution of oil from the same spill, since the gas chomatograms of the sediment extracts before and after this time agree in terms of boiling range, boiling point distribution and characteristic detail and since no new spill occurred in that area. The degradation of the oil appears to involve both bacterial utilization and partial dissolution. Our experience with field samples confirms qualitatively those laboratory observations that indicated a decrease in the degradation rate from normal-, to iso- and cycloalkanes and to aromatics. The n-heptadecane to pristane ratio (n-C_{17}/P, Fig. 2) is a sensitive indicator of incipient oil degradation (2, 3). It decreases more rapidly in the marshes and in lightly polluted offshore sediments than at the heavily polluted Station 31; presumably, this reflects differences in the availability of oxygen. At Station 31, n-C_{17}/P remained nearly constant for the initial 3 months; a slight decrease in December 1969 was followed by a rise, which coincided with the steep rise in pollution level at that Station in March 1970. A similar trend in the n-C_{17}/P ratio at more distant stations during the same period suggests the seaward spread of the fuel oil from the heavily polluted marshes and inshore regions during the first winter after the spill (2, 3).

The rate of bacterial degradation, even of the n-alkanes, is much lower in the environment than under laboratory conditions, using aeration, nutrients, agitation and elevated temperatures. After two years small amounts of n-alkanes persist. This is not surprising, however, in view of the well documented geochemical stability of sedimentary hydrocarbons (5, 6). Branched and cyclic hydrocarbons are attacked even more slowly than the n-alkanes; after two years, isoprenoids (phytane, pristane and the C_{18} homologue are evident), alicyclic and aromatic hydrocarbons remain prominent in the polluted sediments.

Mass spectral analyses of the aromatics at Station 31 from March 1970 to April 1971, show a relative increase of the more highly substituted benzenes, naphthalenes and tetrahydronaphthalenes at the expense of the lower homologues, especially of the most soluble compounds, such as naphthalene and the C_1 to C_3 alkylnaphthalenes. This suggests that dissolution is more important than bacterial utilization of the aromatics; the latter process would not show the same molecular weight dependence.

The saturate to aromatic ratio of the fuel oil in the sediments at Station 31 remained nearly constant from March 1970 to April 1971. Thus the *overall* rate of depletion of the saturated and aromatic hydrocarbons is the same, even if there is preferred bacterial degradation or dissolution of some components within each group.

Analyses of a core from Station 31 in September 1971 show the presence of fuel oil to a depth of 7.5 cm below the sediment surface. Judging from the n-C_{17}/P ratio, the oil below 2.5 cm is as fresh after 24 months as the oil at the surface was after 10 months (3). In the marshes, penetration has been greater, extending to at least 60 cm, and bacterial degradation and dissolution is evident at that depth; this is probably the result of the greater permeability and aeration of the marsh sediments.

Some properties of the fuel oil have changed little, in spite of its gradual degradation. Initially, the boiling range of the spilled oil, extended from 170–370° C and the normal alkanes ranged from decane to docosane. The boiling range of the fuel oil in the sediments is well preserved after two years, even at stations with low pollution level C_{13}–C_{14} alkanes are still present; at Station 31 and in the marshes dodecane can still be detected.

Adjacent members of the same or of closely related homologous series are affected by weathering to nearly the same degree; therefore, their concentration ratios change only slowly. Thus, the pristane/phytane ratio at Station 31 has remained 1.17 ± 0.09 during two years (Fig. 2). This value differs characteristically from that encountered in unpolluted recent sediments (7). The pristane/phytane ratio and similar isomer ratios are distinguishing features that vary between different crude oils. That they are so persistent suggests that the identification of fossil fuel pollutants in the environment and their distinction from the natural hydrocarbon background may be possible over extended time periods.

Our continuing investigation will provide a framework for the consideration of the effect and fate of oil pollution in the coastal environment. Hydrocarbons in the boiling range of the oil spilled at West Falmouth are abundant in crude oil. Smith (1968), in summarizing analyses of 6496 crude oils, showed that the "gas oil" content of the vast majority ranges from 20–35%, except for Tertiary oil, where higher values occur (8). Smith defines gas oil as boiling between 200° C at 760 mm and 225° C at 40 mm or 335° C at 760 mm). This range is comprised within that of this fuel oil (170°–370° mm). Thus, the "fuel oil" component, in the sense of the oil spilled at West Falmouth, constitutes one quarter to one third of the weight of a large majority of all crude oils. Therefore, we anticipate that the environmental effect and the persistence of a crude oil spill resembles that of a fuel oil spill qualitatively, and to a degree quantitatively. The presence in whole crude oils or residual oils of less rapidly degraded and less soluble hydrocarbons of higher molecular weight should lead to greater environmental persistence.

The preservation of hydrocarbons in marine sediments for geologically long time spans is one of the accepted key facts in the current thought on petroleum formation. Similarly, the uptake of dietary hydrocarbons in the food chain and their preservation in the lipids of organisms seems to be well documented. Our present findings do not contradict these background data.

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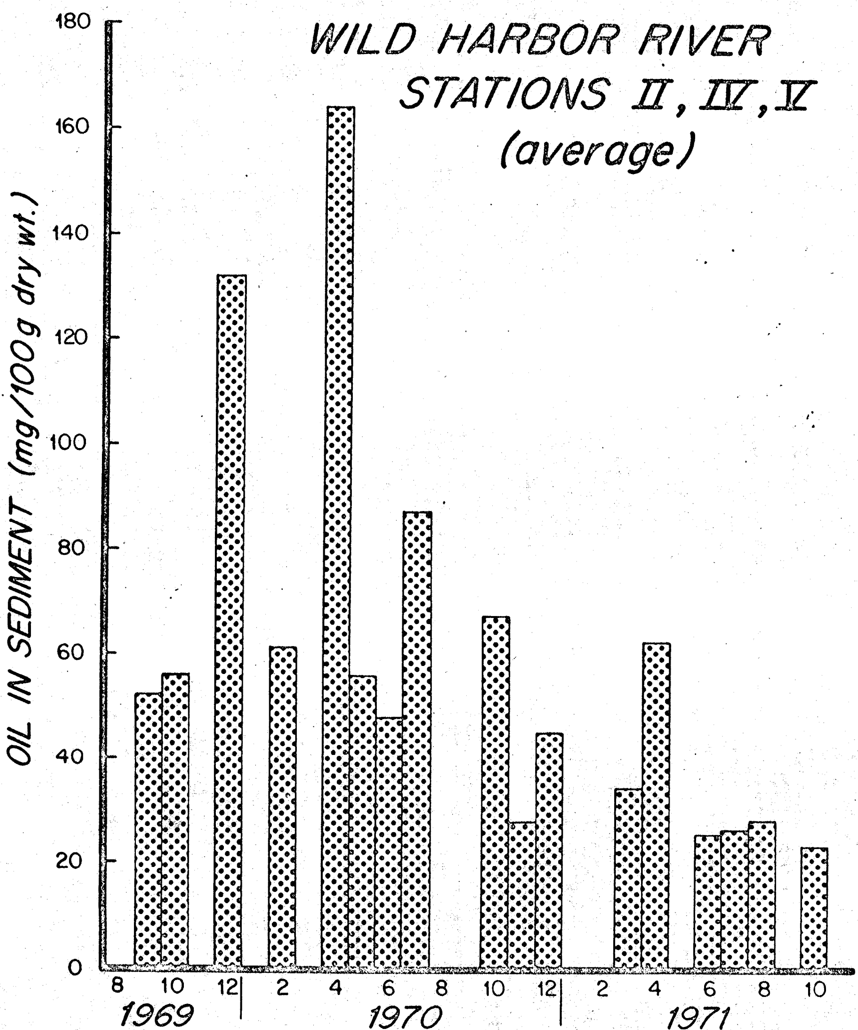
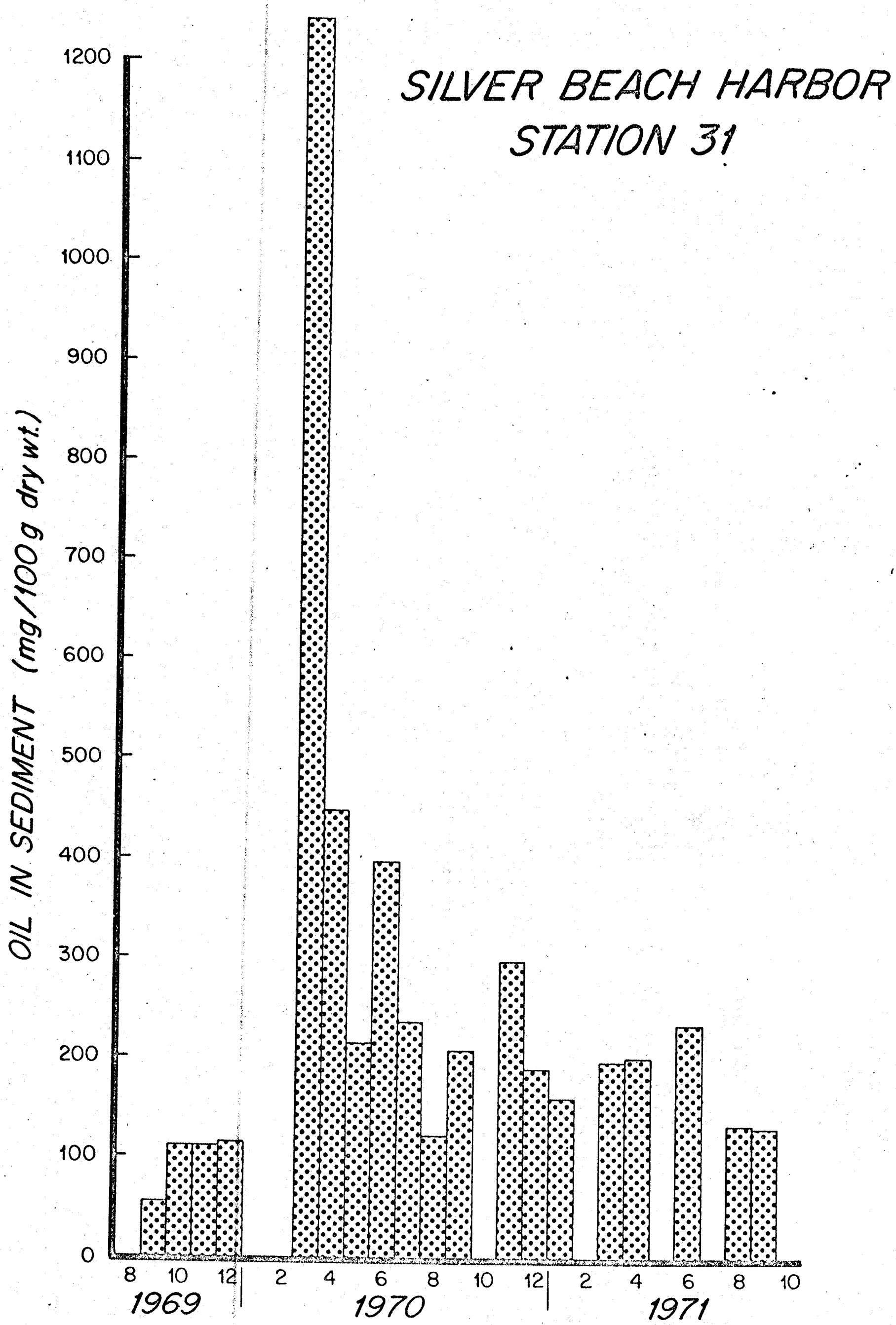
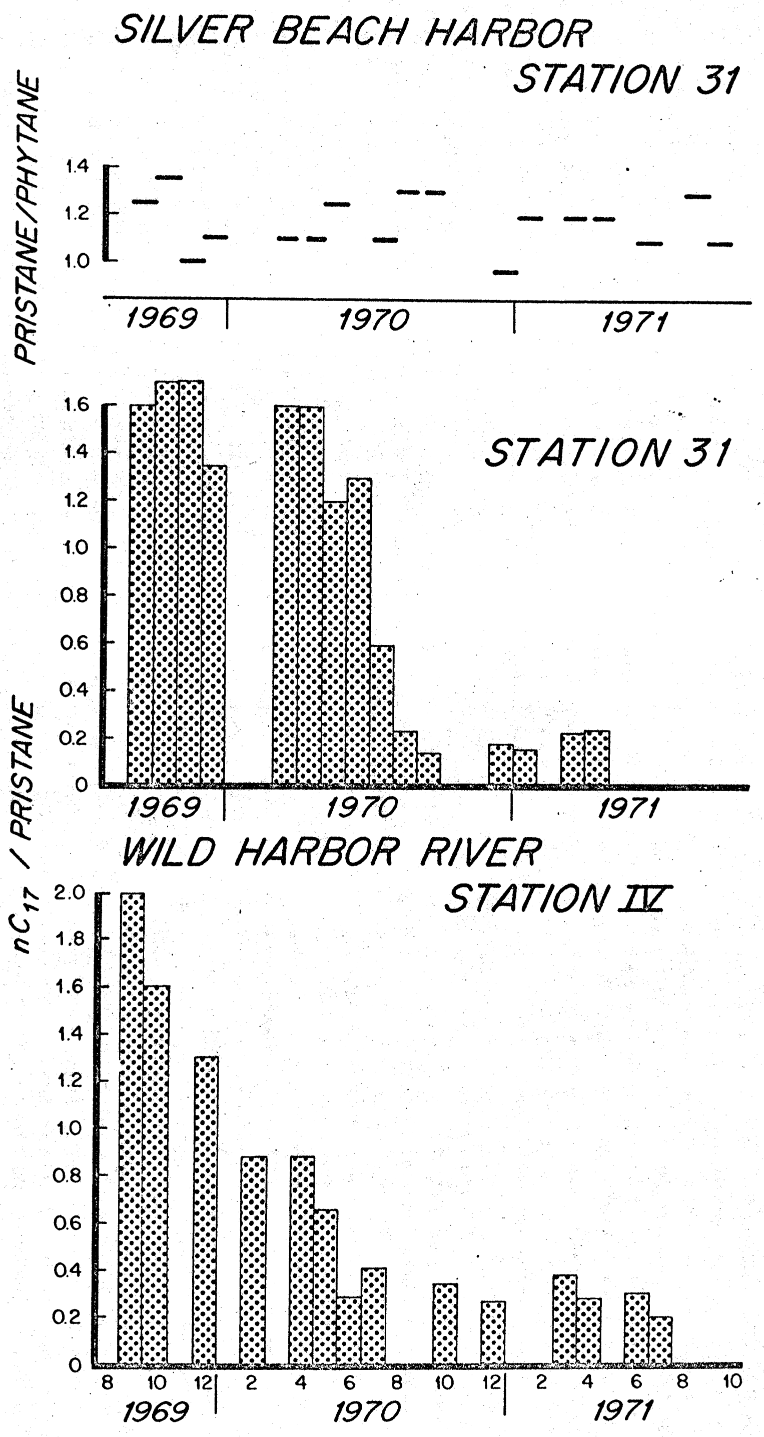
Legends

Figure 1. Hydrocarbon content of marsh and offshore sediments, affected by the September 1969 fuel oil spill in Buzzards Bay, Massachusetts, U.S.A.

Figure 2. The pristane/phytane and the n-heptadecane/pristane ratio in sediments affected by the Buzzards Bay oil spill.


WILD HARBOR RIVER
STATIONS II, IV, V
(average)
OIL IN SEDIMENT (mg/100g dry wt.)
0
20
40
60
80
100
120
140
160
180
8
10
12
2
4
6
8
10
12
2
4
6
8
10
1969
1970
1971


SILVER BEACH HARBOR
STATION 31
OIL IN SEDIMENT (mg/100g dry wt.)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
8
10
12
2
4
6
8
10
12
2
4
6
8
10
1969
1970
1971



SILVER BEACH HARBOR
STATION 31
PRISTANE/PHYTANE
1.4
1.2
1.0
1969
1970
1971
STATION 31
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
1969
1970
1971
nC17 / PRISTANE
WILD HARBOR RIVER
STATION IV
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
8
10
12
2
4
6
8
10
12
2
4
6
8
10
1969
1970
1971

Determination of Polycyclic Aromatic Hydrocarbons in Oysters Collected in Polluted Water

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▶ As barnacles take up polycyclic aromatic hydrocarbons from polluted surroundings, it was of interest to know whether other marine animals living in water polluted with petroleum oils or tars also contain such hydrocarbons. As an investigation of edible marine animals is of particular practical interest, oysters collected in a moderately polluted harbor area were chosen for the present investigation. The nonsaponifiable matter obtained from an oyster extract was fractionated in a series of chromatographic separations, and the fractions thus obtained were investigated spectrophotometrically. The analytical procedures used are also applicable to other complex mixtures. The spectrophotometric investigation of the chromatographic fractions led to the detection of a number of polycyclic aromatic hydrocarbons. They amounted to about 1 mg. per 1 kg. of shucked oysters.

SEVERAL years ago a group of research workers at the California Institute of Technology noticed that extracts obtained from barnacles exhibited a strong blue fluorescence in ultraviolet light (*9, 10, 16, 17*). They showed that the fluorescence was caused by a mixture of polycyclic aromatic hydrocarbons, among which were benzo[*a*]pyrene and a few weak carcinogens. When they investigated different batches of barnacles (*9, 10, 17*), they found that the amount of polycyclic aromatic hydrocarbons as well as the composition of the hydrocarbon mixture varied considerably, depending on the habitat of the barnacles. In one batch no polycyclic hydrocarbons could be detected at all. From this it can be concluded that the polycyclic aromatic hydrocarbons found in certain batches were only "accidentally" present rather than normal metabolites, and that their uptake depends greatly on the environment in which the barnacles live.

In view of these findings it was of interest to investigate other marine animals, particularly edible ones, because a health problem might arise if sea food originating from areas where the water is polluted with tars or petroleum oils were heavily contaminated with polycyclic aromatic hydrocarbons. Oysters were chosen for the present investigation because they live in rather shallow water, where they are frequently exposed to floating pollutants and because they are sedentary, filter-feeding animals like barnacles.

The present paper describes the methods used to detect and identify a number of polycyclic aromatic hydrocarbons in a batch of oysters collected in a moderately polluted area. A methanolic extract of the oysters was fractionated by solvent partition, alkaline hydrolysis, and a series of chromatographic separations. The chromatographic fractions thus obtained were evaluated spectrophotometrically.

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MATERIALS AND INSTRUMENTS

n-Pentane, commercial grade, Phillips Petroleum Co.

Iso-octane (2,2,4-trimethylpentane), pure grade, Phillips Petroleum Co.

Cyclohexane, commercial grade, Phillips Petroleum Co.

Benzene, reagent grade.

Acetone, reagent grade.

Methanol, synthetic, 99.9% pure.

All solvents contained fluorescent impurities and were therefore purified. Methanol was refluxed and distilled over freshly precipitated silver oxide; all other solvents were shaken with charcoal (Norit A) (*14*), then distilled two to three times until neither the distillate nor the residue exhibited any fluorescence in ultraviolet light. Acetone was distilled over anhydrous calcium sulfate (Drierite), the other solvents were distilled without a drying agent. The first and last 5% of the distillates were discarded.

Iso-octane, Spectro grade, Phillips Petroleum Co., was used only for spectrophotometric purposes.

Activated alumina, grade Al-0109 P, Harshaw Chemical Co., reactivated by heating 24 hours at between 190° and 210° C.

Partially deactivated alumina, prepared from the reactivated alumina by addition of water (*15*). Two activity grades containing 3 and 6% of water were used.

Partially deactivated silica gel, Davison Chemical Corp., silica gel, grade 922 (mesh size "thru 200") or 963 (mesh size "thru 325"), was reactivated by heating 24 hours at between 160° and 180° C. From this reactivated silica gel various activity grades were prepared by adding from 3 to 12% of water. The preparation and the chromatographic properties of partially deactivated silica gel have been described (*2*).

Celite, grade 545, Johns-Manville Co.

Nitrogen. Seaford nitrogen, Air Reduction Co., Baltimore, Md., containing not more than 0.002% of oxygen.

Ultraviolet light source. A light beam from a General Electric H 100-A4 mercury arc bulb was passed through a condensing quartz lens and a Corning filter No. 5840 (*1*).

Spectrophotometer. Cary recording spectrophotometer, Model 11 MS, Applied Physics Corp., Pasadena, Calif.

Glassware. All glassware was thoroughly cleaned by scrubbing and soaking in a detergent, then was rinsed several times with water and distilled water.

ANALYTICAL PROCEDURE

Preparation of Nonsaponifiable Matter. The oysters (*Crassostrea virginica*) were collected in a harbor area in the vicinity of Norfolk, Va., a few hundred yards off the shore, shucked, and immediately thrown into methanol. An oyster extract was prepared as shown in Fig. 1. Five kilograms of shucked oysters in 6 liters of methanol were ground under nitrogen in a Waring Blendor. The ground material was filtered in a basket centrifuge. The filtrate was returned to the basket until it was practically free from suspended solid material. The filter cake was shaken with methanol and the mixture was again centrifuged. This process was repeated several times until the filtrate became almost colorless.

All filtrates were combined. Upon standing in the cold (3° C.) they deposited a small amount of solid material. The supernatant fluid was siphoned off and the residue was centrifuged and washed with methanol by centrifugation. The combined green

Table I. Appearance of Column in Ultraviolet Light after First Chromatographic Fractionation

Section (from Top to Bottom)	Approx. Width of Zones, Mm.	Appearance in Ultraviolet Light
A	5	Nonfluorescent (red in daylight)
B	15	Pale blue fluorescence
	55	Nonfluorescent
	5	Pale yellow fluorescence
	35	Nonfluorescent
C	3	Blue fluorescence (purplish blue on top, becoming gradually pale light blue)
D	77	Extremely faint light blue fluorescence

supernatant solutions (24 liters) were almost clear. They were shaken with cyclohexane. The greenish yellow hypophase was extracted several times with cyclohexane until the originally dark green epiphase had only a faint greenish tint. The combined epiphases were dried over sodium sulfate, evaporated under reduced pressure to ca. 500 ml., and saponified by shaking with 250 ml. of a 7*N* methanolic potassium hydroxide solution for 4 hours. Water was added and the mixture was shaken gently. The organic layer was washed successively with water, 1*N* sulfuric acid and again with water. [In spite of prolonged washings with 1*N* sulfuric acid followed by washings with water, the final wash water was still slightly alkaline (pH 8).] The organic layer was dried over potassium carbonate. The clear green solution was decanted from the potassium carbonate, because filtration was made impossible by the presence of a transparent gelatinous material. This was removed by centrifugation at 0° C. The supernatant solution was concentrated under reduced pressure to about 150 ml. The green concentrate exhibited a weak blue fluorescence in ultraviolet light. Upon standing in the cold (3° C.) some more transparent gelatinous material appeared in the solution. This small amount was not removed.

Chromatographic Fractionations. The solution of nonsaponifiable material was mixed with a small amount of Celite, to prevent clogging of the chromatographic column. It was then chromatographed on a 74 × 195 mm. column of partially deactivated alumina (3% water). The chromatogram was developed with cyclohexane containing increasing amounts of acetone, up to 2%. Development was discontinued when the originally green eluate had become only faintly colored. The filtrate was practically nonfluorescent in ultraviolet light. The column was extruded and cut into four sections [A through D (Table I)]. The adsorbed material in each section was extracted with acetone and transferred to cyclohexane (section A) or to *n*-pentane (sections B, C, and D) using the method of LeRosen (*13*). The solutions thus obtained (fractions A through D) were further fractionated in a series of chromatographic separations. In these the liquid chromatogram technique was applied and the movement of the various zones was observed by occasional inspection of the columns in ultraviolet light. From five to 15 eluate fractions that varied in size from less than 1 to 25 ml., depending on the widths of the fluorescent or nonfluorescent zones emerging from the column, were collected in each of these fractionations. The absorption spectra of all fractions were determined. Adjoining fractions having similar absorption spectra were combined and each group of fractions was then rechromatographed. This process was repeated as often as was necessary to obtain eluate fractions whose absorption spectra were sufficiently differentiated to permit the spectrophotometric identification of individual polycyclic aromatic hydrocarbons.

Flowsheets for the chromatographic fractionation of fractions C and D, shown in Figures 2 and 3, illustrate the adsorbents, solvents, and column sizes used. Various activity grades of activated alumina and of silica gel were used as adsorbents. They were prepared by the partial deactivation of the activated adsorbents with small amounts of water (*2*, *15*). Nonpolar eluents such as pentane or iso-octane were sufficient for the complete elution of even penta- and hexacyclic aromatic hydrocarbons from strongly deactivated columns, while with not deactivated or weakly deactivated columns solvents of higher eluting power had to be used. The polarity of the eluent was increased in a stepwise fashion by the addition of small increments of acetone or benzene to a nonpolar solvent. It was found advantageous to use weakly deactivated or not deactivated adsorbents in the early stages of the chromatographic resolution of the nonsaponifiable matter.

In these early stages relatively large amounts of complex mixtures of substances having greatly different adsorption affinities had to be separated. Under these conditions strong adsorbents in conjunction with eluents of gradually increasing eluting power offer the required versatility. In the later stages of the chromatographic fractionation procedure, however, when only very small amounts of material of relatively uniform chromatographic behavior had to be fractionated, use of the more strongly deactivated adsorbents generally gave better results. Broad single chromatographic zones were thus obtained, which could be collected in a series of eluate fractions. Spectrophotometric investigation of these fractions revealed that at least a partial separation of the adsorptives had taken place within the single chromatographic zone. Had the same mixture been chromatographed on an adsorbent of much higher adsorptive strength with a polar solvent as eluent (particularly with acetone-containing

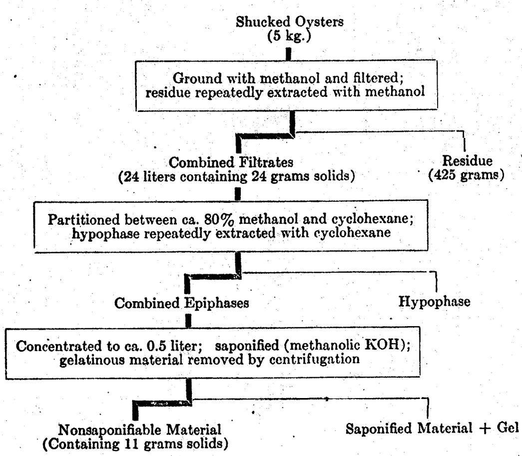

Figure 1. Flowsheet for preparation of nonsaponifiable matter

solvent mixtures), a very narrow single zone would have been obtained. It could not have been collected in a series of eluate fractions, and separation would therefore not have been achieved.

Appropriate conditions (choice of adsorbent, eluent, and adsorbent-adsorptive ratio) were determined in some cases in preliminary test runs. In other cases they could be predicted from the chromatographic behavior of the eluate fraction in the preceding fractionation step. This behavior is easily observed by inspection of the column in ultraviolet light. The adsorbents, eluents, and column sizes that were chosen permitted satisfactory fractionations in most instances. However, no attempts were made to determine optimal conditions for each chromatographic fractionation. The adsorbent-adsorptive ratios varied from 50 to 1000. The higher ratios (ca. 500 to 1000) were required when relatively weakly adsorbed hydrocarbons were chromatographed on strongly deactivated adsorbents—e.g., fractions D-III-2 and D-III-4, Figure 3 in which case broad zones were obtained. All columns were wet-filled.

The flow rate was adjusted by means of nitrogen pressure so that the solvent above the adsorbent moved from 4 to 12 mm. per minute. The slower flow rates (4 to 6 mm. per minute) were used only with very short columns (up to about 40 mm.). Silica gel, grade 922, offers less resistance to the solvent flow than silica gel, grade 963. The latter was used only for the preparation of very short columns when the use of grade 922 would have resulted in too high flow rates. All chromatographic fractionations were carried out in subdued artificial light (General Electric fluorescent lamp Gold) in order to prevent photodecompositon (cf. *1*). For the same reason the columns were irradiated only momentarily for the inspection of fluorescent zones.

Spectrophotometric Identification of Polycyclic Aromatic Hydrocarbons. Absorption spectra of all eluate fractions were determined from about 210 to 400 or 500 mμ with a recording spectrophotometer. Some of the fractions, which contained only solvents that do not absorb ultraviolet light, were investigated directly. All other fractions were evaporated to dryness under reduced pressure and in an atmosphere of nitrogen; then the residues were taken up in iso-octane, spectro grade. Spectra in the near-ultraviolet region were in some cases also determined in benzene, *n*-pentane, or cyclohexane, because the spectra of some polycyclic, aromatic hydrocarbons show differences in fine structure in different solvents. Such changes can be of considerable help in the spectrophotometric analysis of certain eluate fractions. Figure 4 shows changes in the fine structure of the benzo[*a*]pyrene spectrum in the neighborhood of 380 mμ. These changes permit one to distinguish benzo[*a*]pyrene from benzo[*ghi*]perylene, even in eluate fractions in which the short wave ultraviolet portion of the spectrum is difficult to evaluate because of high background absorption. The spectra of the various eluate fractions were always first determined at high concentrations in which the lower peaks at longer wave lengths become more easily discernible; then at lower concentrations which are appropriate for the determination of the higher peaks in the lower wave length regions. The peaks at higher wave lengths, although much lower, are of particular value for the identification of individual hydrocarbons because little background absorption is present in this region. The peaks at lower wave lengths are frequently superimposed on a high background absorption and are therefore somewhat obscured (*1*).

The absorption spectra of the eluate fractions obtained in the first chromatographic fractionation of the nonsaponifiable matter (fractions A,B,C,D) were atypical. The characteristic fine structure of the spectra of polycyclic aromatic hydrocarbons was completely lacking. Many of the eluate fractions obtained in the next fractionation step (C-I- and D-I fractions in Figures 2 and 3) yielded spectra that showed a number of peaks, humps, and inflections. Although some of the spectra suggested the presence of polycyclic

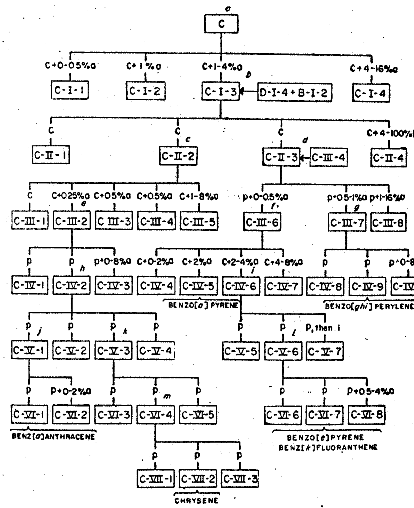

Figure 2. Flowsheet for chromatographic fractionation of fraction C

a. 600 mg. of solute; activated alumina + 3% of water, 9 × 260 mm.
b. 400 mg. of solute; activated alumina + 3% of water, 5 × 200 mm.
c. 11 mg. of solute; silica gel + 6% of water, 6 × 80 mm.
d. 21 mg. of solute; activated alumina + 3% of water, 6 × 60 mm.
e. 8 mg. of solute; silica gel + 12% of water, 6 × 140 mm.
f. 18 mg. of solute; silica gel + 12% of water, 6 × 300 mm.
g. 0.8 mg. of solute; silica gel + 12% of water, 6 × 70 mm.
h. 7 mg. of solute; activated alumina + 6% of water, 6 × 180 mm.
i. 1 mg. of solute; silica gel + 12% of water, 5 × 35 mm.
j. 0.8 mg. of solute; silica gel + 6% of water, 5 × 30 mm.
k. 0.7 mg. of solute; silica gel + 12% of water, 5 × 35 mm.
l. 0.4 mg. of solute; silica gel + 12% of water, 5 × 30 mm.
m. 0.2 mg. of solute; silica gel + 12% of water, 5 × 30 mm.
p = *n*-pentane; i = iso-octane; c = cyclohexane; b = benzene; a = acetone

Designations in boxes represent groups of eluate fractions

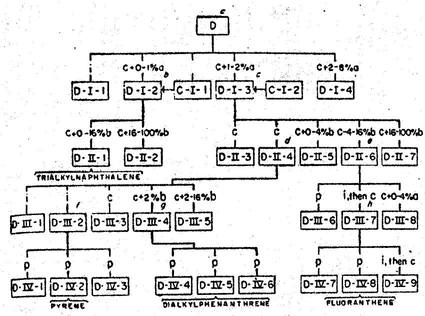

Figure 3. Flowsheet for chromatographic fractionation of fraction D

a. 900 mg. of solute; activated alumina + 3% of water, 9 × 270 mm.
b. 90 mg. of solute; activated alumina + 0% of water, 6 × 100 mm.
c. 100 mg. of solute; silica gel + 3% of water, 6 × 100 mm.
d. 6 mg. of solute; silica gel + 6% of water, 6 × 180 mm.
e. 14 mg. of solute; silica gel + 12% of water, 6 × 340 mm.
f. 2 mg. of solute; silica gel + 12% of water, 6 × 150 mm.
g. 10 mg. of solute; silica gel + 12% of water, 6 × 380 mm.
h. 5 mg. of solute; activated alumina + 3% of water, 6 × 100 mm.

p = *n*-pentane; i = iso-octane; c = cyclohexane; b = benzene; a = acetone

Designations in boxes represent groups of eluate fractions

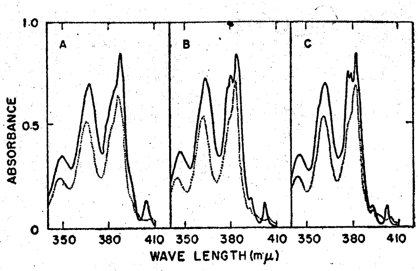

Figure 4. Absorption spectrum of benzo[*a*]pyrene and of benzo[*ghi*]perylene

——— Benzo[*a*]pyrene, 3.3 γ per ml.
...... Benzo[*ghi*]perylene, 3.1 γ per ml.

Solvent. *A* = benzene; *B* = cyclohexane; *C* = *n*-pentane
2-Cm. cells

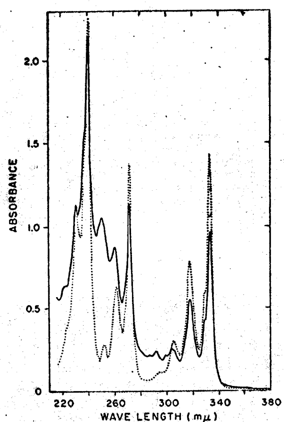

Figure 5. Absorption spectrum of eluate fraction containing pyrene

——— Fraction from oysters
...... Pyrene

Solvent. Iso-octane
2-Cm. cells

aromatic hydrocarbons, they were not yet sufficiently differentiated to permit the identification of individual compounds. At best it could be concluded from the general shape of an absorption curve that certain types of hydrocarbons—e.g., phenanthrenes or pyrenes—were predominant in that fraction. A comparison of the spectra obtained with those published by Charlet, Lanneau, and Johnson (*5*) for certain types of aromatic hydrocarbons proved to be of help in this tentative group characterization. The following fractionation step yielded fractions (C-II- and D-II- fractions in Figures 2 and 3) in whose spectra the typical peaks of individual hydrocarbons could be clearly recognized. The spectra indicated, however, that most fractions contained mixtures of two or more hydrocarbons, although frequently one of them was predominant. One or two additional chromatographic fractionations were usually required for the unequivocal spectrophotometric identification of the various polycyclic aromatic hydrocarbons.

The identification of the hydrocarbons present in the various eluate fractions was based on a comparison of the spectra obtained with those of authentic samples of pure hydrocarbons determined under identical conditions. The reference samples were obtained from various research laboratories and commercial sources. They were purified chromatographically before use. A mere similarity of certain spectra with those published in the literature for a large number of aromatic hydrocarbons (*7*) was never considered sufficient proof of identity. Only by means of reference substances was it possible to compare spectra obtained under absolutely identical conditions and to determine the exact location of all peaks and valleys with a high degree of precision. With the instrumental setup used the location of sharp peaks could be determined with a precision of better than ± 1 mμ.

If an eluate fraction contained essentially a single hydrocarbon and only small amounts of contaminants, identification of the hydrocarbon offered no difficulties. The spectrum of the eluate showed then all peaks and valleys of the corresponding reference spectrum while no major additional peaks and valleys were present. Only some background-absorption in certain wave length regions indicated that the eluate fraction still contained some contaminant. An example of such an easily identifiable spectrum is given in Figure 5. (In Figures 5 and 6 the concentration of the reference substance was chosen arbitrarily, to permit an easy comparison of spectra.) If an eluate fraction contained two or more hydrocarbons, an interpretation of its spectrum became more complicated because each hydrocarbon present contributes its typical absorption peaks to the spectrum of the eluate fraction. Nevertheless, it was frequently possible to establish with certainty the identity of the hydrocarbons present in such mixtures by applying the variable reference technique described in detail by Jones, Clark, and Harrow (*8*). This spectrophotometric technique consists essentially of the gradual addition of one or several components of a mixture to be analyzed to the solvent in the reference cell of a spectrophotometer until the contribution of these components to the spectrum of the mixture is completely eliminated by compensation. In the present investigation a special reference cell as recommended by Jones and others was not used. The substances were added in small increments to the reference cell and the spectra were determined after each addition.

Figure 6 illustrates an application of the variable reference technique. The spectrum of the eluate fraction suggested the presence of chrysene and of benz[*a*]anthracene. When benz[*a*]anthracene was added to the reference cell, a compensated spectrum was obtained which was almost identical with the spectrum of an authentic sample of chrysene. Similarly, compensation with chrysene resulted in a spectrum almost identical with the one of pure benz[*a*]anthracene.

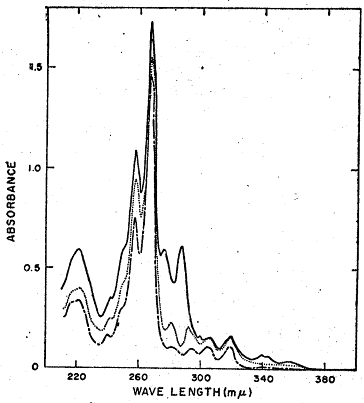

Figure 6. Absorption spectrum of eluate fraction containing chrysene and benz[*a*]anthracene

——— Fraction from oysters
...... Fraction from oysters, compensated with benz-[*a*]anthracene
—·—· Chrysene

Solvent. Iso-octane
2-Cm. cells

Table II. Approximate Amounts of Polycyclic Aromatic Hydrocarbons in Extract from 5 Kg. of Shucked Oysters

Compound	Approximate Amount, γ
Benzo[*ghi*]perylene	5–25
Benzo[*a*]pyrene	10–30
Benz[*a*]anthracene	<50
Benz[*k*]fluoranthene	40–60
Benzo[*e*]pyrene	<100
Chrysene	100–200
Pyrene	500–800
Fluoranthene	3000–5000

For a rough estimation of the amounts present in the various eluate fractions the base line technique described by Cooper (*6*) was used. The relative height (not the absorbance) of a typical absorption peak is measured and compared with the relative height of the corresponding peak in the spectrum obtained from an authentic sample of the hydrocarbon. Absorption peaks in the higher wave length region were selected for this determination because in this region there is least interference from background absorption.

RESULTS

The polycyclic aromatic hydrocarbons which could be identified spectrophotometrically and the approximate amounts present in the extract from 5 kg. of shucked oysters are listed in Table II. Certain eluate fractions contained a compound tentatively considered to be a trialkylnaphthalene. Other fractions contained a compound tentatively identified as a dialkylphenanthrene. These tentative identifications were made on the basis of the similarity of the spectra of the eluates with those of 2,3,6-trimethylnaphthalene and of 1,7-dimethylphenanthrene, 1-methyl-7-isopropylphenanthrene, and 1-ethyl-2-methylphenanthrene, respectively. One of the eluate fractions seemed to contain perylene in trace amounts insufficient for positive identification. Table II (which does not include the naphthalenes and phenanthrenes) shows that the hydrocarbons which could be identified with certainty in the nonsaponifiable matter obtained from 5 kg. of oysters amounted to about 4 to 6 mg. Of the 11 grams of nonsaponifiable matter, 7.7 grams consisted essentially of a gelatinous material that passed rapidly through the column of activated alumina in the course of the first chromatographic fractionation. The bulk of the remaining 3.3 grams (fractions A, B, C, D) consisted of sterols (mainly ostreasterol), red, yellow, and green pigments, and other unidentified substances. Among these may have been some highly alkylated hydrocarbons (cf. *5*) for which reference compounds could not be obtained. The isolation of ostreasterol from fraction B has been described (*3*). The chromatographic resolution of fractions A and B, carried out in a fashion similar to that shown for fractions C and D, revealed the presence of only minimal traces of strongly adsorbed polycyclic aromatic hydrocarbons insufficient to permit an identification.

DISCUSSION

The procedure used for the preparation of the nonsaponifiable matter was based on the method described by Zechmeister and Koe (*17*) for barnacles. The only difficulty encountered was the formation of emulsions during the washing of the saponified extract. Several cross washings were necessary in order to prevent appreciable losses of material. In the solvent partition step several extractions of the hypophase with cyclohexane were required for the complete transfer of the polycyclic aromatic hydrocarbons to the epiphase.

Silica gel and activated alumina were chosen as the adsorbents in the chromatographic fractionations on the basis of preliminary experiments in which the chromatographic behavior of various polycyclic aromatic hydrocarbons on a number of adsorbents was investigated. In these experiments partially deactivated silica gel, and to a somewhat lesser degree activated alumina and partially deactivated alumina, yielded the best defined chromatographic zones. Considerable trailing was observed on columns of Magnesol and Florisil, two brands of magnesium trisilicate. The adsorptive strength of the brand of

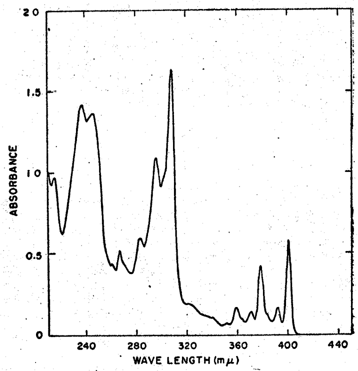

Figure 7. Absorption spectrum of benz[k]fluoranthene

Concentration. 3.2 γ per ml.
Solvent. Iso-octane
2-Cm. cells

activated alumina used (Harshaw) was similar to that of the widely used Alcoa brand, F-20, 80 to 200 mesh. The Harshaw brand was, however, preferable because of its finer mesh size. Activated alumina Woelm (alkaline) gave broader zones than the Harshaw and Alcoa brands. On changing from alkaline to neutral and acid alumina (Woelm), the zones became increasingly broader. The addition of 3% of water to activated alumina yields an adsorbent whose adsorptive strength is slightly inferior to that of a silica gel containing 6% of water. An activated alumina partially deactivated with 6% of water and a silica gel partially deactivated with 12% of water have roughly comparable adsorptive strengths.

The adsorption sequence of the various hydrocarbons present in the oyster extract (in general, the same for silica gel and activated alumina, but frequently different for hydrated lime) is shown in Figures 2 and 3. The eluate fractions which yielded the best spectra of individual hydrocarbons are indicated. Alkylation increases the adsorptive strength of the parent hydrocarbon; pyrene is more strongly adsorbed than phenanthrene but less strongly than dialkylphenanthrene.

Benz[k]fluoranthene is adsorbed only slightly more strongly than benzo[a]pyrene. Its spectrum shows a peak at 400 to 401 mμ in iso-octane (Figure 7), while the spectrum of benzo[a]pyrene has a small peak at 403 mμ (Figure 4). This is of practical interest because the quantitative evaluation of benzo[a]pyrene in crude mixtures such as tars or oils is frequently based on a measurement of the height of the 403-mμ peak, after chromatographic fractionation of the mixture. A contamination of benzo[a]pyrene containing eluate fractions with benz[k]fluoranthene will then simulate more benzo[a]pyrene than is actually present. A complete separation of these two compounds from each other is therefore necessary before a quantitative evaluation can be attempted. Benz[k]fluoranthene has been found in shale oil (*4*) and in atmospheric samples collected in a petroleum- polluted area (*12*, *cf. 11*). Experiments now under way to determine whether or not benz[k]fluoranthene has carcinogenic properties will be reported.

The amounts of the polycyclic aromatic hydrocarbons shown in Table II, particularly of benzo[a]pyrene which is frequently, although without much justification, used as an indicator for the carcinogenicity of crude oils and tars, appear to be extremely small, if one considers that Zechmeister and Koe isolated 100 mg. of crude benzo[a]pyrene (40 mg. after recrystallization) from thatched barnacles. However, the same authors obtained only 360 γ of crude benzo[a]pyrene from the peduncles of another batch of barnacles originating from a different habitat. (Yields are calculated for 5 kg. of starting material.) Still another batch, collected at a third location, was practically free from polycyclic aromatic hydrocarbons (*9*, *10*, *17*). The oysters used in the present investigation were collected in an area which was only moderately polluted with petroleum oils. There was no evidence of tar pollution. It must be assumed that the quantities of polycyclic aromatic hydrocarbons in oysters vary, as in barnacles, with their habitat. The significance of the quantitative results presented in this paper can therefore not be evaluated until several batches of oysters collected at different locations have been analyzed. Qualitatively, the present investigation shows that oysters, like barnacles, are able to take up polycyclic aromatic hydrocarbon from polluted surroundings.

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Hydrocarbon pollution of edible shellfish by an oil spill*

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Abstract

A spill of 650,000 to 700,000 l of No. 2 fuel oil has contaminated the coastal areas of Buzzards Bay, Massachusetts (USA). Gas chromatography demonstrates the presence of this oil in the sediments of the affected area. Two months after the accident, essentially unchanged oil is still being released from the sediments. The presence of the same pollutant is demonstrated in whole oysters *Crassostrea virginica* and in the adductor muscle of the scallop *Aequipecten irradians*. A presumably biochemical modification leads to a gradual depletion of the straight chain and, to a lesser extent, of branched chain hydrocarbons. This does not result in detoxification, as the more toxic aromatic hydrocarbons are retained in the organisms several months after the accident. Scallops from an uncontaminated area contain hydrocarbons in lesser amounts and of very different molecular weight and type distribution; they are accountable entirely from biological sources.

Introduction

Hydrocarbons are universal components of the marine environment. Synthesis by marine organisms results in a surprising variety of hydrocarbons (Blumer et al., 1963, 1964; Blumer and Thomas, 1965a, b; Blumer, 1967; Blumer et al., 1969) that spread through the environment because of their relatively great stability in the food chain and their resistance to degradation in seawater and in marine sediments (Blumer and Snyder, 1965; Blumer, 1969a). Hydrocarbons from pollution by fossil fuels and oil products are being found in increasing amounts; it has been estimated that at least 1 million metric tons of oil and oil products are released annually into the ocean, mostly in shipping lanes and in biologically productive coastal regions (Blumer, 1969a, b, c). Hydrocarbons in fossil fuels and pollution differ from the natural, biogenic hydrocarbons in organisms. They are more toxic, mostly because of the higher content in aromatic hydrocarbons, and are less readily degraded by bacteria.

The persistence of oil slicks on the high seas and the stability of biogenic hydrocarbons in the food chain have suggested that pollutants might remain in the ocean for long time periods. A possible incorporation of dispersed fossil fuels into the food chain might eventually contaminate food products derived from the sea.

An opportunity to test these assumptions came with a recent oil spill near Woods Hole, Massachusetts. On September 16, 1969, the barge "Florida", transporting 14,000 barrels (2,220,000 l) of No. 2 diesel fuel oil[1] (aromatic hydrocarbon content 41%) came ashore off Fasset's Point, West Falmouth, in Buzzards Bay, and released an estimated 650,000 to 700,000 l fuel oil along the shores of West and North Falmouth, Massachusetts (Hampson and Sanders, 1969). A strong SW gale carried much of the oil towards West Falmouth Harbor and Wild Harbor. Both Harbors were closed off by floating booms. After 2 to 3 days, the wind shifted to NE and the remaining oil slick moved out of the Buzzards Bay Area. Detergents were applied in limited areas for a short time. After the spill, a drastic kill of fish, worms, crustaceans and molluscs was noticed almost immediately, before detergents had been applied. It extended into the inshore areas upstream from the floating booms. Oil was incorporated into the sediments to at least 10 m of water depth, probably because of the intense mixing of oil and water by the gale force winds. Studies were initiated by biologists at this Institution and at the Marine Biological Laboratory, Woods Hole, to assess the immediate damage. Investigations will be extended over at least 1 year in order to study the effect of the spill on the faunas and to determine the fate of the oil in the organisms and sediments.

Some of the productive shellfish beds upstream from the affected areas had remained viable; however, they were closed to the taking of oysters and scallops because of possible contamination. On September 25, 1969, taste tests suggested that shellfish could be taken safely and the areas were reopened. However, commercial exploitation yielded scallops with objectionable "oily" taste; this led again to a closing of the shellfish areas on September 27, 1969. At that time a joint effort

* Contribution No. 2444 of the Woods Hole Oceanographic Institution.

[1] Personal communication, F. M. Wong, Federal Water Pollution Control Administration, New England Basis Office, Needham Heights, Massachusetts.

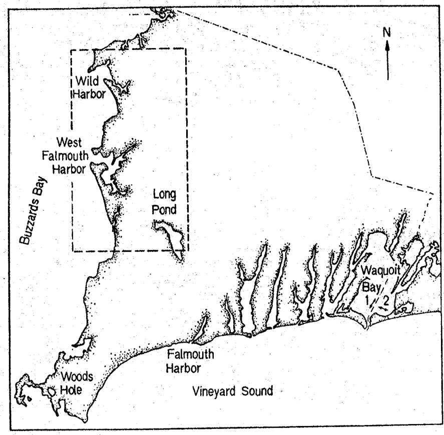

Fig. 1

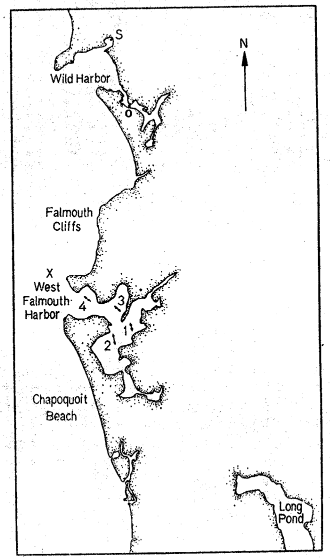

Fig. 2

Fig. 1. Southwestern Cape Cod, Massachusetts (USA). Uncontaminated oysters *Crassostrea virginica* were taken at sites 1 and 2 in Waquoit Bay. For site of accident and contaminated samples see detail, Fig. 2

Fig. 2. Site of accident (X). Samples taken at Wild Harbor. S sediment; O oysters *Crassostrea virginica*. Scallop (*Aequipecten irradians*) samples from West Falmouth Harbor (1—4)

between the Town of Falmouth and this laboratory was initiated to determine the possible pollution of oysters and scallops by this accident and to advise on further closing or reopening of the shellfish areas.

Scallops *Aequipecten irradians* were collected in West Falmouth Harbor on November 4 and oysters *Crassostrea virginica* in Wild Harbor River on November 12 (Figs. 1 and 2). For comparison, uncontaminated scallops were collected on the same date from Waquoit Bay on the South Shore of Cape Cod, Massachusetts.

Experimental methods

Extraction

Immediately after collection, the animals were taken to the laboratory. They were shucked as for commercial use, but care was taken to avoid contamination. The whole oysters, excluding the shell but including any liquid, and the scallops (the adductor muscles of *Aequipecten*) were weighed and transferred to paper thimbles that had been Soxhlet-extracted for 24 h with redistilled methanol.

The samples were extracted with refluxing methanol for a total of 20 h. This was interrupted by 3 soaking periods, 35 h in total, during which the specimens remained in the methanol-filled thimbles at room temperature. Methanol in the receiving flasks was changed once to minimize foaming and bumping.

The extracts were combined and solids were removed by centrifugation; these solids were then extracted by vigorous stirring with pentane, followed by centrifugation. The extraction was repeated 3 times. The original extracts, freed from solids, were extracted in separatory funnels with 4 batches of pentane. These pentane extracts and those from the solids were combined, washed with water to remove the remaining methanol, dried with extracted sodium sulfate, and concentrated on a rotary evaporator below room temperature. The vacuum was removed immediately when a drop in pressure indicated that the pentane had been removed.

All solvents used were analytical grade and were redistilled in all glass stills through packed columns.

Chromatography

Samples were chromatographed from a minimum volume of pentane on a column, packed in pentane, consisting of 3 parts of silica gel (Davison, grade 922, through 200 mesh, activated at 120 °C and then deactivated with 5% water, by weight) and 2 parts of alumina (Harshaw, 0102-P, activated at 250 °C and then deactivated with 5% water). The silica gel was packed first as an even layer and the alumina was packed over it as a separate top layer. The dual column gives better retention of higher molecular weight polar materials than silica gel, and better resolution of the hydrocarbons from nonhydrocarbons than alumina alone. Deactivation of the column with water prevents the formation of hydrocarbon artefacts from biogenic nonhydrocarbons, e.g. the formation of phytadienes from phytol (Johnstone and Quan, 1963; Blumer and Thomas, 1965b). The column dimensions were chosen for a minimum adsorbent to sample ratio of 50. The columns were eluted with 4 column volumes of n-pentane.

The suitability of the chromatographic technique for the analysis of No. 2 fuel oil was checked; a sample of the oil involved in the accident at West Falmouth was chromatographed and gave a recovery of 98.7 ± 1%. Analysis for other, heavier, oils might require a technique modified for the elution of the higher molecular weight and more polar components by mixtures of pentane with benzene.

The sediment extracts contained elemental sulfur in addition to the hydrocarbons, this was removed on a column of precipitated copper (Blumer, 1957). The chromatographic eluates were dried and taken up in a known quantity of carbon disulfide. A small aliquot was evaporated on an aluminum pan and weighed on a Cahn Gram Electrobalance. The remainder of the CS_2 solution was used for gas chromatography. The hydrocarbon composition of the No. 2 fuel oil involved in the accident was analyzed by column chromatography. The oil (80.0 mg) was charged to a column of activated silica gel (15 ml) in pentane and eluted with pentane (15 ml, 15 ml, 30 ml), and with pentane containing 10, 30 and 50% benzene (30 ml, 30 ml, 50 ml). The 6 fractions were freed from solvent, weighed and analyzed by UV spectrophotometry in pentane. Fraction 1 was saturated and accounted for 58% of the total oil. Fraction 2 (0.8%) was mixed saturated and aromatic, while the remaining fractions (41%) were fully aromatic and increased in aromatic ring numbers from benzenes in fraction 3 to naphthalenes in 4, and phenanthrenes in 5. The weight of fraction 6 was negligible.

Gas chromatography

The equipment consisted of a Varian Aerograph 600 D gas chromatograph, with linear temperature programmer, 1 mv recorder and automatic attenuator. Columns were 10 ft., 1/8″ o.d. packed with 2.2% Apiezon L on Chromosorb W, 70 to 80 mesh, acid washed, siliconized. For injection, the column was cooled below 100 °C; after elution of the CS_2 the oven temperature was programmed from 100° to 300 °C at 6 C°/min. Duplicate analyses were run, alone and after the addition of an internal standard containing the n-paraffins from decane to eicosane.

Discussion of chromatograms

The gas chromatogram (Fig. 3 A) of the No. 2 fuel oil involved in the accident shows the presence of normal paraffins approximately from decane ($C_{10}H_{22}$) to docosane ($C_{22}H_{46}$), with a maximum in the C_{12} to C_{15} range. The estimated boiling range of the oil is 170° to 370 °C, with the largest fraction distilling between 200° and 300 °C. In addition to the straight

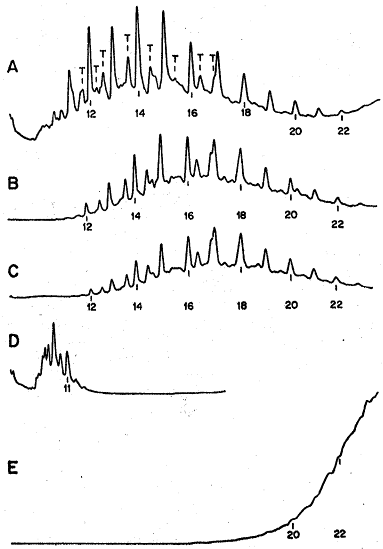

Fig. 3. Gas chromatograms. (A) No. 2 fuel oil; (B) sediments in Wild Harbor Basin, 12 days after accident; (C) oil recovered from water in Wild Harbor Basin, 2 months after accident; (D) 2-cycle outboard motor oil; (E) SAE No. 10 Lubricating oil. T marks position of isoprenoid alkanes