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OFFSHORE INSTALLATIONS AND THEIR RELEVANCE TO THE COAST GUARD THROUGH THE NEXT TWENTY-FIVE YEARS

VOLUME III
APPENDICES

AD A100672

by:

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16. Abstract

This three-volume study forecasts the universe of offshore installations (OSI) in waters proximate to U.S. territory out to the year 2005, and assesses the impact of the growth in numbers and types of these installations on the Coast Guard.

Volume I describes the global, regional, national, and subnational forces operating to promote or inhibit the growth of the OSI universe; presents a forecast of the OSI universe resulting from the impact of these forces; describes the likely impact of this growth on the Coast Guard; suggests a set of alternative strategies that appear feasible and promising for the Coast Guard; and offers recommendations for the Coast Guard.

Volume II presents detailed forecasts of a variety of categories of offshore installations related to energy, food, minerals, industrial expansion seaward, military and space, transportation, and science and technology.

Volume III contains appendices for each of the key chapters of Volume II; the data and rationale supporting the forecasts of Volume II are presented.

The conclusions of the study are summarized:

o By the year 2005 the population of oil and gas OSI will have expanded very significantly; OTEC installations will be a distant second; all other types of OSI will be a still farther distant third.

o The expansion of the OSI universe will increase the operating load on the Coast Guard enormously by the year 2005; there will be a strong need for decision to either expand Coast Guard capability or to reduce Coast Guard load.

o The study recommends that the Coast Guard opt to move in a direction that makes maximum use of its unique operational capability, if necessary at the expense of its regulatory and other nonoperational roles.

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PREFACE

This report is submitted under provision of contract No. CG-916668-A with the U.S. Coast Guard to make a forecast of offshore installations to the year 2005. The study is one of several conducted or sponsored by the Coast Guard in an effort to ascertain the likely impact upon the Coast Guard of events between now and the end of the century.

The context of the study is the growing realization that the once abundant resources of our industrialized economy, including space, are becoming less available from their conventional sources on land. This is resulting in a seaward movement of our search for resources, which in turn is impacting upon the environment in which the Coast Guard has traditionally operated, with a significant increase in the demands being placed upon the Coast Guard.

Concurrently with this increased demand, the Coast Guard confronts a period of budget austerity, and in addition is experiencing the constraints of inflation that face all institutions dependent on federal appropriations.

The scope of the study is determined in large measure by the Coast Guard's definition of "offshore installation" to be a structure either fixed to the sea floor or capable of keeping station within a small radius.

The report is in three volumes:

- Volume I contains a description of the research process, forecasts of the macro and marine environments, forecasts of the offshore installations, implications to the Coast Guard, and the study team's recommendations.
- Volume II contains detailed forecasts of offshore installations together with the basic data and rationale for their derivation.
- Volume III consists of a set of appendices: one associated with each of Chapters 2 through 8 in Volume II, and a general appendix.

VOLUME III

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INTRODUCTION TO VOLUME III

The material in this volume was originally intended as merely an accumulation of some of the more basic data required for the report. However, much of this material appears to be relevant to any effort that a reader might have to audit the rationale through which we arrived at our conclusions at the various stages. We are therefore submitting this data, in the context in which it was collected, as an ancillary volume for reference use. One of our recommendations is that the Coast Guard develop and institutionalize a monitoring system for maintaining a "track" on the precursors identified in the report. This appendix will be useful to those interested in pursuing this recommendation.

In a very general sense, each chapter-related appendix in this volume follows the approximate format of Table 1 below. This table originated as the basic data collection structure early in the study to be used by researchers gathering the relevant data. For various reasons peculiar to the topic or the circumstance of collection, the format is not completely filled in for all topics for each chapter. However, it is filled in for all items considered highly relevant to the study effort.

TABLE 1

APPROXIMATE FORMAT FOR CHAPTER-SUPPORTING APPENDICES

1. Operational system description
2. General description of mission
3. Historical development
4. Current level of activity
5. Projected activity
6. Geographical characteristic
7. Onshore impacts
8. Primary motivating factors, barriers, obviating factors
9. Development process
10. Forecasts

APPENDIX TO CHAPTER 2 OF VOLUME II -- ENERGY

OFFSHORE MISSION CATEGORY: Energy: Oil & Gas Extraction

1. Mission of Operating System: Oil & Gas Extraction.

2. General Description of Mission: Find and produce petroleum in commercial quantities. The mission is comprised of three major operational components:

   a. Exploration
   b. Production/transportation
   c. Logistic support

3. Historical Development: The first offshore oil well began production in 1896 off California. It was drilled from piers built 800 ft. offshore. From this modest beginning, offshore production of oil and natural gas has grown steadily in both volume and locations.

As relatively inexpensive land based oil and gas resources became less capable of filling the seemingly inexhaustable demand for petroleum-based products by the industrialized world, the potential represented by offshore deposits received growing attention. Recent developments which have spured awareness of the "energy problem" caused a growing priority to be placed on development of America's offshore oil and gas reserves.

Historically and today, oil and gas are the most important mineral resource being extracted from the sea, and they are likely to remain so well into the future. Since the beginning of the industry at the turn of the century, any growth has been heavily technologically dependent. This continues to be the case. Technical developments have allowed wells to move farther from shore and into deeper water in harsher climates. Indeed, all of the technical developments in platform design and in configuration improvements in other type of offshore installations allowing for planning for different sorts of offshore missions such

as power plants or industrial complexes have been based upon solutions to the technical problems of offshore oil and gas extraction.

Major Milestones

- o 1896 - First trend platform drilling occurs off coast of California.
- o 1946 nine wells drilled from support structure in immediate shallow water off Louisiana Coast.
- o Early 1950's saw crude attempts of the development of near offshore rigs by floating barges into shallow water with drilling equipment attached onto the barges. Many World War II surplus ships were also tried in this capacity.
- o Late 1950, saw a greater sophistication in the use of early drillships. Beams were connected to the ship and operated on the side of ship. Blowout punctures was mounted on top at the draw pipe.
- o 1954-1964--Marked a decade of technological inventiveness from which most mobile rig techniques were designed .
- o 1953--First time mobile rigs began construction in Gulf of Mexico (submersibles)
- o 1955-1958--First boom was in construction of mobile rigs.
- o 1954-1959--High concentration of submersibles built, currently obsolete.
- o 1954-First jack-up operations in 40 ft. water.
- o Early 1960s saw conversion of submersible technology to development of semisubmersibles. (As movement further offshore began, greater mobility stability requirements had to be met.
- o 1926--First operational semisubmersible.
- o 1963-1966--Project Mohole fosters concepts of self-propulsion and dynamic positioning later adopted on large scale semis.
- o 1960's jack-up capability rapidly exceeds 200 ft.
- o 1970's jack-up platforms used extensively in California. Semis used for exploration and drilling throughout world.

U.S. OFFSHORE PRODUCTION IN HISTORICAL PRODUCTION FIGURES	
Year	Production in Barrels
1953	940634
1954	2723173
1955	5871853
1956	10136355
1957	15373071
1958	23709108
1959	34177529
1960	47359144
1961	61265770
1962	84931909
1963	98331298
1964	114977253
1965	136236062
1966	175187390
1967	205860535
1968	252016345
1969	295429477
1970	337122885
1971	390180091
1972	378497189
1973	360888784
1974	332354155
1975	303159121
1976	316920109
1977	290771605
1978	292265042
1979	not available

4. Level of Activity/Current Usage: U.S. offshore production of gas and oil is presently highly concentrated in the Gulf of Mexico and off the coast of California. The most apparent trend in offshore production is that the number of new and exploratory wells has increased while the total amount of crude has decreased. This reflects the fact that the fields of easily developed oil--those close to shore or in shallow water--have reached maturity and are producing less, while technical and regulatory problems have slowed the opening of new fields. Conversely, the amount of offshore natural gas has steadily risen because of improvements in recovery methods and the rising price of natural gas which has made "marginal" fields economical to produce. A regional breakdown follows:

a) Gulf of Mexico: Daily average crude production: 729,800

Active Rigs: 142

Multi-well production platforms: 984

After 33 years of exploration and production, the Gulf, America's first major offshore oil area, is reaching maturity. It is, however, reaching maturity with what one source terms "hectic grace." The decline in the most senior offshore area in the U.S. is marked by a steady, and expected, decline in crude production. The region is also characterized, though, by very high bonus bidding by oil companies for marginal prospects, intensive filling in operations, and a dramatic expansion of costly drilling in deep water prospects. In the last three years crude oil production has fallen 13% but natural gas production has risen 32%.

During 1979, 1,127 wells were drilled in the Gulf. 345 of that number were considered exploratory by the developers, about 32% of the total. That level is expected to drop in 1980, with 400 exploratory wells out of a total of about 1,450. Fifty one new field discoveries were announced in state and federal offshore waters in 1979. This was up from 32 discoveries in 1978. Most of the dis-

coveries (29 of the 51) made in 1979 were made in Louisiana, Texas had 21. One exploratory well, drilled at the entrance to Mobile Bay, revealed a potential very deep field. Only three of the 51 wells have any kind of crude production--the rest are gas producers. The estimated crude production from those three oil finds, should they be produced, is very small--none of them exceed 1,000 b/d. Any additions to the crude reserves off Louisiana or Texas will come from extension of discovered reservoirs or deeper pools.

Seventy seven platforms were installed in the Gulf during 1979, almost all of which were multi-well drilling and production structures. Current wells are tabulated in the following figures:

DOMESTIC WELLS IN THE GULF AREA

State/District	Oil	Gas	Dry Holes
Louisiana	170	255	254
Texas	6	31	175
Rest of Gulf	5	--	19

Construction of the High Island Gathering System, a 120 mile long crude and condensate pipeline began partial operation last year. The line connects the seven field High Island complex with Galveston, Texas.

In 1979 pipe was laid for the Louisiana Offshore Oil Port (LOOP) System. The LOOP marine terminal is scheduled to open for operations late in 1980 with an initial throughput of 1.4 million b/d. Construction of the terminal complex is virtually complete. It consists of pumping platform, a control platform, 3 single-point-mooring units with 56" pipelines connecting them to the pumping platform and a 48" pipeline connecting the pumping platform to shore. Additionally, OFFSHORE reports the following usage trends in the Gulf area:

- Much work on subsea completion systems and other alternatives to the fixed steel platform for deep water production.
- The heavy use of jackups for filling-in operations and to deepen older fields.
- Increased use of ship drilling units or semisubmersibles for operations in shallow water.
- Commencement of production by the world's tallest platform, Shell's Cognac platform off the mouth of the Mississippi River, located in 1,025 ft., of water. The production target is 50,000 b/d.

Operators whom drilled in deep water were Phillips, (3), Exxon (6), Unical (2), Chevron (1) and Socal (1). The most promising area appears to be the apparently oil prone Mississippi Canyon area, where eleven of the thirteen wells were drilled. The other wells are placed in the East Banks area.

b) California - Daily average crude production: 114,600.

Active rigs: 5

Multi well production platform: 9

As in the case of Gulf of Mexico, California's offshore production is declining, but there is speculation that two recent developments will reverse the trend:

- Exxon appears to be well on the way to beginning production from the Hondo field in the Santa Barbara Channel
- Platform numbers are showing a high increase.

Mitigating those developments is that little exploratory work has yet to be carried out in tracts leased in the last round of OCS sales. Even though more than ten months has passed since OCS sale 48, operators have not been able to get the necessary clearance to begin exploration.

More than any other area on the American OCS (with the exception of Georges Bank, should lease sales take place there), pollution control is a major trend and problem in California waters. For example, Exxon won the bulk of the tracts making up the rich Hondo, Sacate and Pescado fields in 1968 and made the first strike in 1969. The company has been fighting a battle with federal and state pollution control agencies ever since. A memorandum of agreement was signed in 1979 that may result in those fields going into production. Exxon agreed to install extensive anti-pollution equipment, including equipment that will capture hydrocarbon vapors and sulfur recovery units, the state agreed to allow construction of an onshore gas retreatment plant 20 miles west of Santa Barbara. The gas will be distributed to the L.A. area.

There are presently 20 platforms offshore California, including 16 in the Santa Barbara Channel and four off Southern California. Two additional platforms are scheduled for completion in 1980 in the Santa Barbara Channel. In addition to the platforms, seven artificial islands are being used for oil production. Six are off Southern California and one is in the Santa Barbara Channel. The following figure tabulates the present effort offshore California:

Oil Wells	Gas Wells	Dry Holes
79	94	18

c) Alaska: Daily average offshore crude production: 105,120

Active rigs: 6

Multi well production platforms: 14

According to all forecasters and researchers, the offshore Alaska picture' is by far the brightest on the U.S. OCS. But most of Alaska's promise is as yet untapped, and so will be covered in Section 5 below. Within the next five years

Interior will offer a number of tracts for sale. Most interest centers on the northern side of the Aleutian Islands and Prudhoe Bay, although there is production beginning or scheduled to begin in the Beaufort Sea. Extensive exploratory effort has been directed toward the Lower Cook Inlet against a backdrop of several dry holes. The first exploratory well drilled in 1979 did strike oil, but not in commercial volume. Five other wells have been drilled and abandoned. Present knowledge and environmenmtal concerns indicate that Gravel Islands rather than production platforms will be used in the Prudhoe and Aleutian lease areas.

The following is a tabulation of present activity in Alaska offshore:

State/Federal Waters	Oil	Gas	Dry Holes
State	5	-	1
Federal	-	-	4

d) East Coast: Daily average crude production: 0

Active rigs: 4

Production Platforms: 0

The 27 month drilling history offshore the east coast is not meeting expectations. The most promising area of the Baltimore Canyon just resulted in a dry hole--the 18th since exploratory activity began on the eastern OCS in 1978. Natural gas has been discovered, but it is not yet known if those strikes will prove to be of commercial quality.

Exploration of the next most promising area of the east coast has not yet begun, even though there was a very successful lease sale in December 1979. Before exploration can begin in Georges Bank, litigation against offshore operations

in that area must be settled. Six wells have been drilled in the area; all have been dry.

	Oil	Gas	Dry Holes
Domestic East Coast Wells	-	-	18

5. Projected Use, Trends, and Technological Forecasts

Forecasts of future offshore activity vary widely. Some forecasts indicate 82,000 offshore wells by 1990, while others predict 56,000. Optimistic forecasters feel that offshore production will lead to American near-energy independence, while others argue that offshore production will have virtually no impact on reliance on imported oil. Even the fairly well known Gulf area is subject to great variation in forecasted reserves.

The outlook for Alaska shows more optimism than for any other U.S. frontier area. USGS estimates Alaska's undiscovered offshore resources in a range of seven to 32 billion bbl of oil and 30 to 97 trillion cubic feet of gas. To make a comparison, the entire Pacific Coast OCS potential is estimated within a range of between 1.5 and 5 billion bbl of oil and 1.5 to 6 trillion cubic feet of gas. The Gulf is forecasted in a range of 0.5 to 5 billion bbl of oil and 12 to 49 trillion cubic feet of gas, while the east coast OCS is depicted within a range of 0 to 4 billion bbl of oil and 0.5 to 17.5 trillion cubic feet of gas.

The current trends in offshore oil development and in thinking about the future are built on two interrelated foundations: pricing and technology. Oil industry and USGS planners feel that there is a great deal of gas and oil to be exploited in the world--at least as much as has been found to date and perhaps several times as much--which would allow for an orderly transition from the world's present petroleum dependent civilization to a society based on

various alternate energy sources. Such a sanguine view is possible largely because of the offshore potential.

Forecasts off offshore oil trends and discussion of the current "state-of-the-art" seem to hinge on assessments of world petroelum reserves. Throughout this century, as we have learned more about the distribution of petroleum reserves, estimates of petroleum have generally increased, although USGS has drastically reduced its mid-1970's estimates for all U.S. OCS areas, except for Alaska. Oil and gas resources are arrayed along a pattern of reservior size distribution ranging from very large to small fields. There is a relatively small number of giant reservoirs and a relatively large number of small, deep fields. Data available in mature, well drilled areas such as onshore U.S. and offshore the Gulf of Mexico demonstrate that the amount of oil contained in small fields is far larger than that which is preset in very large reservoirs. Therefore, for purposes of planning petroleum reservoirs may be divided into two parts: the base which is "economic" to exploit under a given set of economic and technological conditions; and those fields which are "uneconomic" to exploit under the same set of conditions. Since most petroleum is found in smaller or deeper reservoirs, most is proportionately uneconomical. Therefore, the majority of newly discovered oil accumulations offshore the U.S. are likely to be uneconomic, a projection which current exploration is bearing out.

But, major technological advances and higher oil prices will have drastic effects on the size of the economic petroleum base. Smaller, deeper, or more remote fields become profitable--or economic--and a much larger proportion of the available petroleum base becomes economical. This clearly has been the historic trend, and is itself one of the major reasons for the existance of the offshore oil industry.

Improvements in the "state-of-the-art" of oil discovery have resulted in

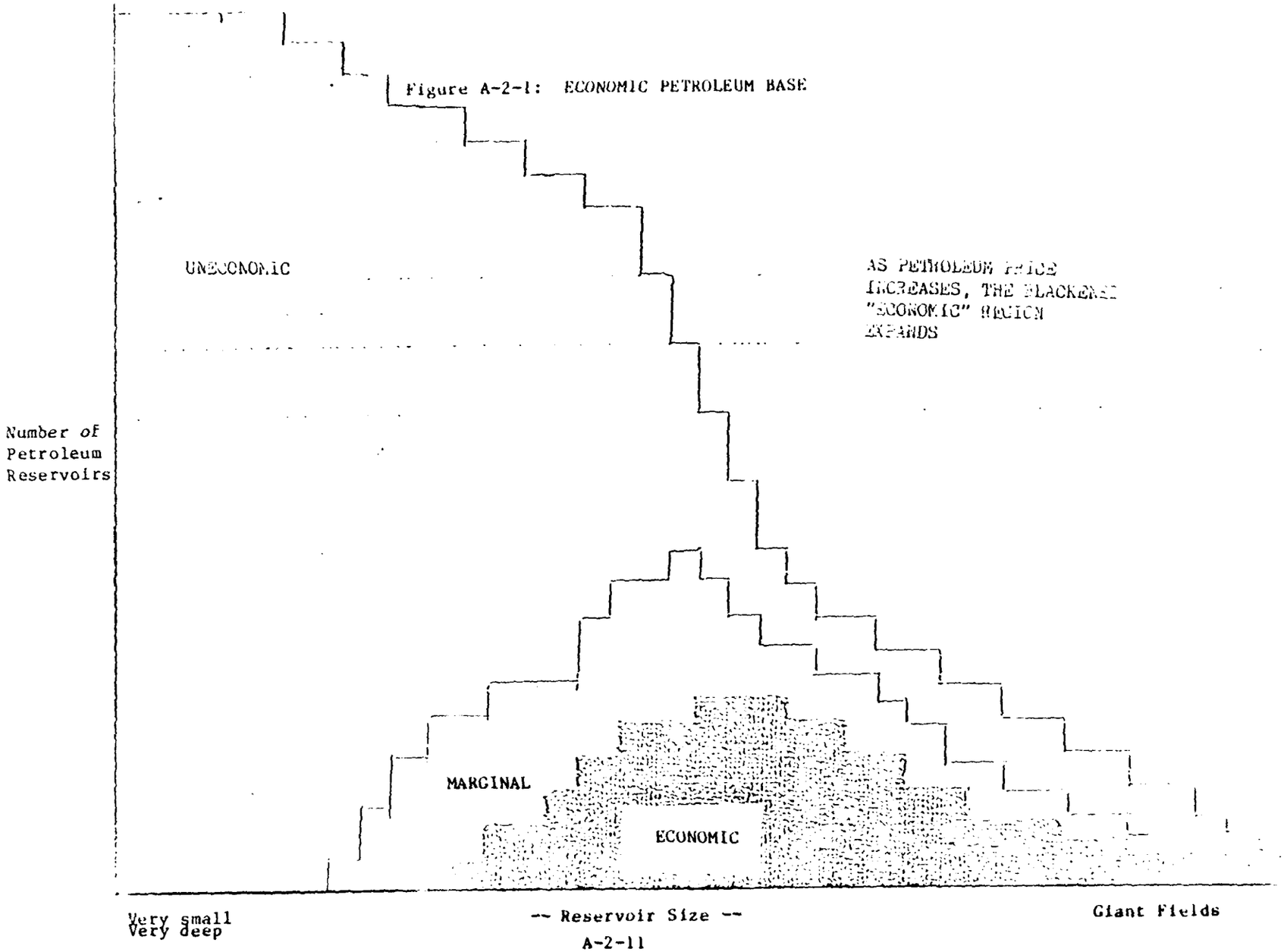


Figure A-2-1: ECONOMIC PETROLEUM BASE

exact classification of the sedimentary basins within which petroleum is formed and trapped. Most of the newly identified basins containing giant, economic fields are situated offshore. Many, perhaps the majority, of these basins are located in harsh climates like Artic Alaska or the deep oceans. For that reason, the ability to exploit these resources is very highly dependent on advances in technology. While there is much R&D effort oriented toward making it "economical" to extract presently uneconomic oil from less harsh or more easily assessable locations (i.e., "filling-in" the Gulf) via improved production techniques, most recent trends are toward advances in searching, drilling, and producing oil in the newly discovered, harsh, giant fields such as those in Alaska.

Some of the newly developed technological advances in oil discovery are:

- Remote satellite sensing providing synoptic view of the earth's surface suitable for geologic mapping.
- Improved seismic processing and interpretation.
- Computer graphics

Some improvements in drilling technology include:

- Increased depth drilling capability.
- Platforms able to withstand arctic weather conditions.
- Air cushion hovering and ice melting capability for over-ice movement.
- Plans have been announced by CONOCO for the world's first tension leg platform, a floating offshore oil producing facility, for the North Sea. This will open the possibility for operating in water depths well beyond the capabilities of existing technology. The platform would be anchored to the sea bottom by twelve tubular steel tethers through mechanical locking devices with the flex joints CONOCO predicts that a tension leg platform will be capable of oil and gas production in over 2,000 feet of water.

- Advances are being made in technologies for deepsea completion projects as they move into deeper waters. Designs, construction materials, and procedures are being used to minimize maintenance and diver concern.

- In 1979 a strain-gauged instrumented riser assembly successfully operated at a 3,700 feet depth. Success was attributed to a total system design with subsea computers at the sensors.

- A raiser angle positioning system (RAPS) has been developed recently which will provide a valuable back-up position reference for dynamically positioned vessels which use the acoustic system as a primary reference. RAPS measures the angle of selected joints in the riser system and uses a mini-computer to develop information on the vessel-well-head position reference. Eventually, RAPS may be used independent of the acoustic system except for comparison.

- Other significant advancements in deepwater drilling:

  - Automated drilling rig: currently being tested for use offshore; by 1981 this type of rigs will probably be in operation offshore the U.S. and Germany.

  - Deepwater production platform advances:

    a. With recent development of larger launch barges and expanded yard facilities on deepwater channels, steel jackets can be fabricated, transported and installed in over 1,000 fett at much lower costs.

    b. During the 1980's existing equipment and facilities will enable conventional platforms to be used at a maximum depth of 1,200-1,300 feet of water.

    c. Concrete gravity platforms have recently been developed which can provide significant oil storage and can accommodate large deck loads. Currently, they have been used in over 500 feet, but are designed for twice this depth. In the 1980's several will be installed in areas subject to moving ice.

       - An articulated steel-concrete gravity tower is being developed for deep water applications in depths ranging from 1,200 to 3,000 feet.

d. Deeper water units of mobile production platform have been evaluated. During the 1980's several will probably be constructed.

e. Oscillating towers: have been constructed for flare towers and tanker loading terminals; several test programs are being undertaken to develop technology for using them as deep water production platforms. During the 1980's they will be used as deepwater production devices at a minimum depth of 1,500-2000 feet.

f. Guyed tower-Exxon plans to install it in deep water off Louisiana.

g. Tension leg platforms - water depths of 2,000-3,000 feet appear currently feasible.

- Subsea production systems: under development and in use since the early 1960's, but have not developed as expected. The deepest subsea product systems presently are in about 500 feet of water.

  a. One company is considering the installation of a subsea production system, in about 2,500 feet of water.

  b. A European company has plans for a subsea production system to produce into a dynamically positioned tanker, which will function as a production and transport unit; it is expected to be ready by 1982.

- Production riser test programs are underway or are being considered for funding.

- Pipelines will probably be laid in the 2,500-3000 range during the 1980's.

- Loading terminals: present technology will enable Single Anchor Leg Moorings (SALM) articulated columns to be extended into water depths of about 2,000 feet (as compared to the current record of 520 feet for SALM). Loading terminals in depths over 2,000 feet may require a combination of currently known concepts with several articulations built into the riser or column in order to handle high loads and substantial movements.

- Experimental submersibles can dive up to 20,000 feet, but will require modifications for use in offshore oil operations. Technological development of such units should be feasible during the 1980's

o A steel platform utilizing a combination floatation chamber-storage tanks at the base of the structure has been designed by Howard Doris. The chambers would be used to stabilize the platform during towing of the platform in vertical position and could be used as storagetanks.

o A quantum input of new technology and testing is required for exploration and production of the Arctic shelf. Potential installations/structures which may or have been constructed for this harsh environmental include:

  - Variety of mobile steel and concrete platforms, especially in depths beyond the economic range of artificial islands. Platforms are specially designed to meet and deal with forces from ice sheets. Three concepts in the designs are: 1) heating system to prevent ice from bonding to the hull; 2) shaped to permit failed ice to move past the hull; 3) inclined/declined plane surface at water level to bend and shear sheets of ice.

  - Air-cushioned transport vessels for moving equipment to across Arctic ice and air-cushioned vessels capable of supporting drilling rigs and equipment while drilling over ice or water.

  - Artificial islands: 20 have already been constructed in the offshore Canadian Arctic since 1973 which have served as rig foundations for drilling exploratory holes. They are constructed of ice, gravel, sand and silt.

o A dynamically positioned semi-submersible monoped with ice-cutting capability incorporated around its vertical column.

o A monoped structure consisting of a one-legged platform supported by a broad submersible base.

o Hydraulic piston corer.

o Extended core barrel.

o Aluminum drill pipe.

o A method of installing three strings of casings.

o Vessel designed for crabbing while supplying offshore structures.

By the mid-to late 1980's the offshore sector of the oil industry is expected to be producing about 30% of non-communist world production. In absolute terms that figure means about 30 million b/d, almost the total production figure for the 1960's. Such an increase will represent a 400% rise in offshore production in just two decades. In general, the total industry figure is 100% of all production.

It is, however, in production rather than in exploration and drilling that the hardest challenges lay. Exploration and drilling techniques already can reach far greater water depths than can be exploited by current production methods. Furthermore, drilling, when compared to production, is still inexpensive. There is an urgent need to develop production systems for deep water and to extend the capability and cost effectiveness of existing production technologies to increase the "economic" oil in current small and deep wells.

An example of this need is a new jack-up design featuring an open-truss platform which costs 1/3 less to produce than conventional types. It is designed to operate in marginal fields.

6. Current and Forecast Geographical Locations

Current locations are given in Section 4 above. Forecasted locations fall within the same areas. The next proposed five-year OCS oil and gas lease sale schedule, to run March 1980-February 1985 was recently announced. The state waters where the proposed action will occur are: Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, California, and Alaska (See attached maps).

7. Onshore Impacts: Onshore socioeconomic and environmental impacts of offshore development of oil and gas are among the most controversial and most variable elements of OCS energy development. While specific categories of on-

here impacts are discussed in the growth model and Chapter 6, the following represent the major categories of impacts of oil and gas extraction:

a. Impact on employment and commercial fisheries
b. Impact on habitats and resources
c. Impact on endangered species
d. Impact on air quality
e. Impact on social and economic infrastructures

   1) urban

   2) rural

   3) native subsistence and culture in Alaska

d. Impact on planning and management for other OCS/near shore uses

8. Primary motivating factors/barriers/obviating factors

Motivating Factors	Barrier	Obviating Factors
Demand for oil and gas higher than domestic on-land capabilities	High capital costs Higher economic risk	Suitable substitute source to fill demand
Need for greater nation supply independence	Uncertainty of finding "economic" field	Substitute consuming systems to reduce demand
Need to reduce foreign exchange balance	Environmental risks	Overriding loss of socio-economic, political stability
Growing awareness of off-shore potential	Conflicting uses Aesthetic considerations	
Increasing technical capacity to locate and tap	Geophysical requirements Tax policies	
Private/governmental in-stitutional capacity and motivation	Regulatory structure Anti-trust concept of natural monopoly	

Continued

Motivating Factors	Barriers	Obviating Factors
Fundamental role of oil and gas based energy systems in the national economy and life style	Oil pipelines on-shore hook-up through-put policy	
Fear of nuclear power	Public resistence to the new	
Need for "bridge" to alternative energy sources		

9. Development Process:

This process is outlined in Chapter 11.

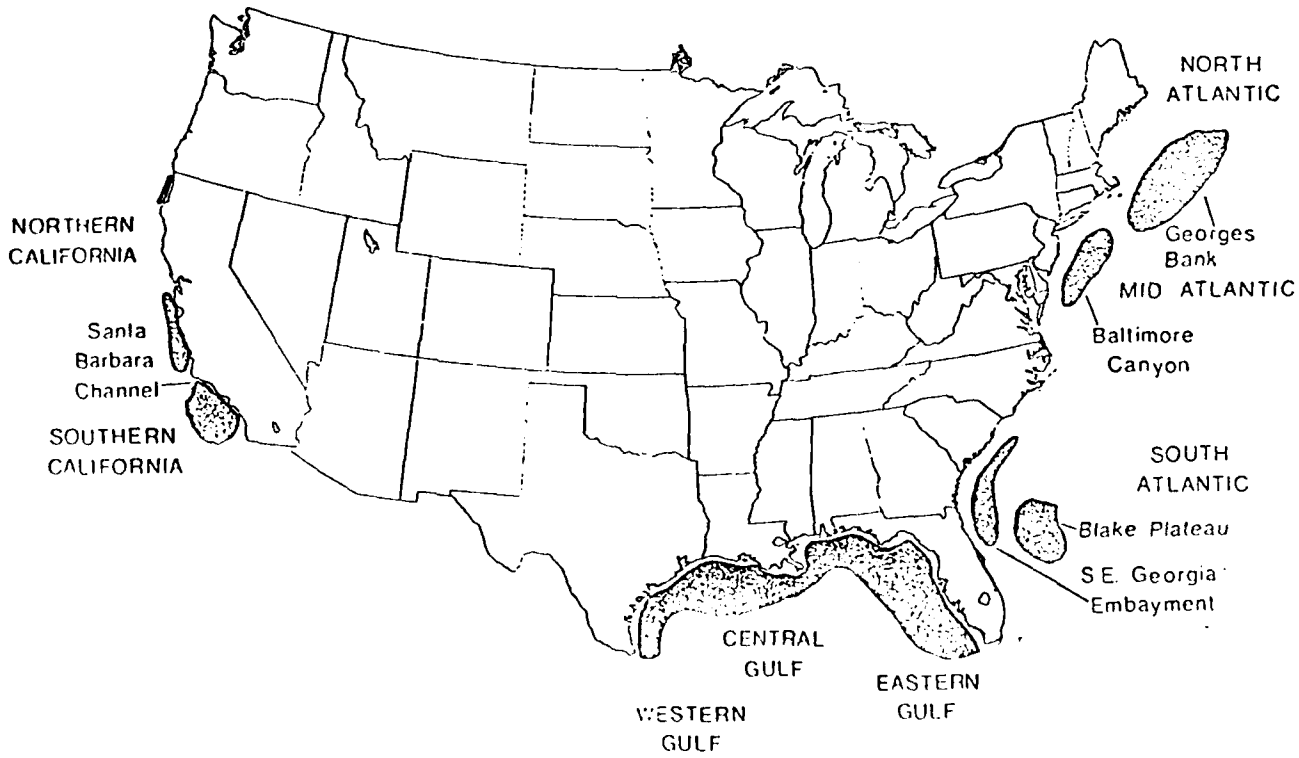
10. Forecasts:	1990-1995	1995-2000	2000-2005
Suitable substitutes for oil and gas will be developed and preclude growth in demand for offshore oil and gas	L	L	L
Demand for oil and gas will decline proportionately but grow absolutely	H	H	H
Substitute consuming systems will be developed offset any increase in demand for petroleum	L	L	M
Socio-political climate will be favorable to responsible exploitation of offshore petroleum	H	H	H
Comparative cost of developing and producing U.S. offshore oil and gas will decline in relationship to the cost of imported or on-land petroleum	H	H	H
Environmental issues will grow in importance	H	H	H
Environmental issues will restrict development of select offshore reserves and slow the development of others	H	H	H

H = High
M = Moderate
L = Low

Continued

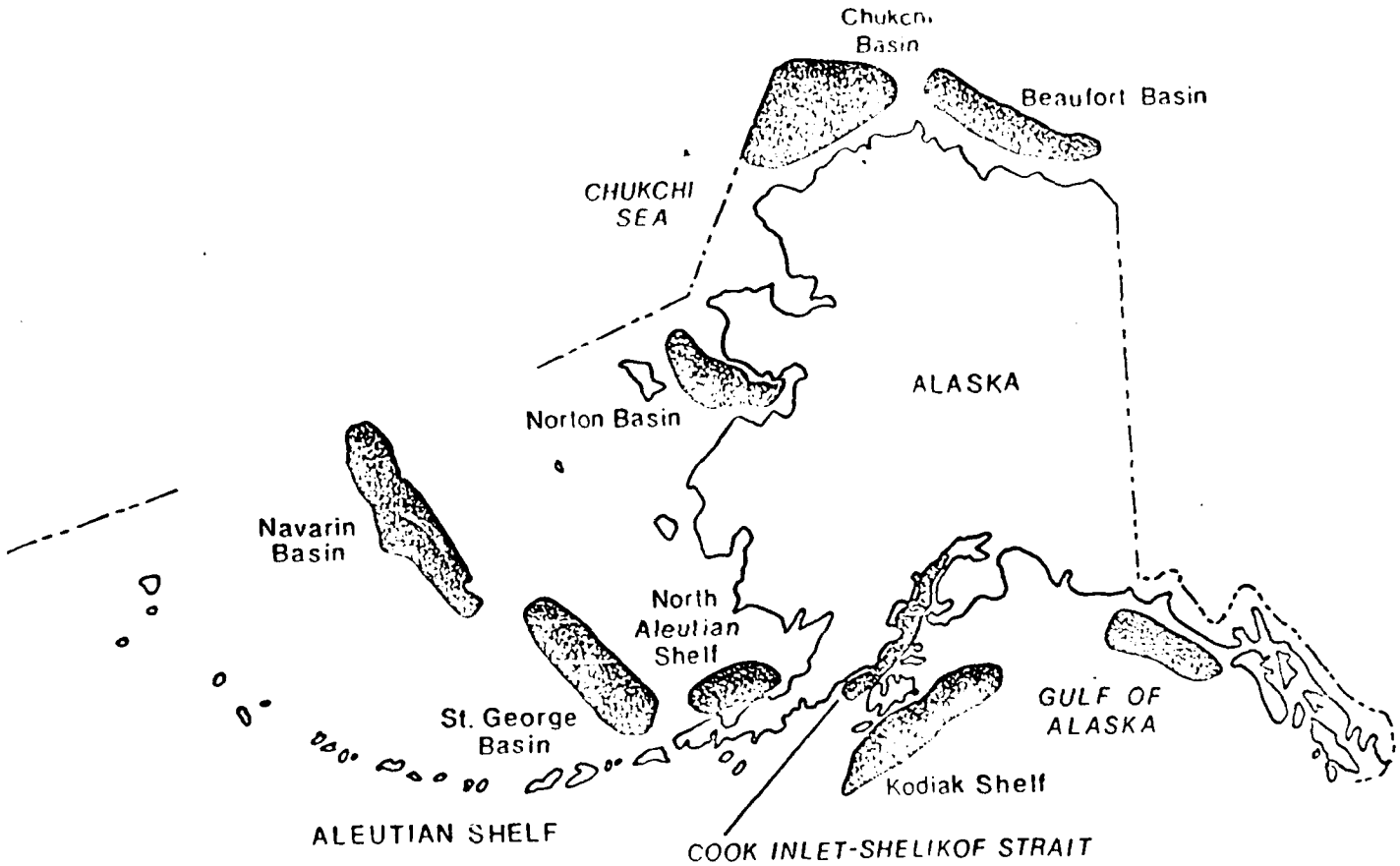
10. Forecasts: (Continued)	1990-1995	1995-2000	2000-2005
Environmental issues will stop or reverse development of all offshore reserves	L	L	L
Environmental safety issues will increase costs of offshore development	H	H	H
Offshore reserves are fully inventoried	L	L	M
Depletion rates for offshore production will be allocated	L	M	H
U.S. production platforms/systems established in areas now considered international waters	M	H	H
Surface Production Platforms			
Continue in widespread use	H	H	H
Operate within harsh environments in water depths up to 10,000 ft.	L	L	M
Enforcement of strict environmental safety standards	H	H	H
Enforcement of strict work area and worker safety standards	H	H	H
Pump crude directly into tankers, including VLLCS	M	H	H
Pump crude directly into feeder pipelines	H	H	H
Pump crude directly into offshore:			
refinery	L	M	H
power plant	L	L	M
industrial complex	L	L	L
Extensive use of sub-sea production systems up to 5,000 ft.	M	H	H
Extensive use of sub-sea production systems below 5,000 ft.	L	L	L

H = High
M = Moderate
L = Low



OUTER CONTINENTAL SHELF LEASE AREAS
OF THE CONTIGUOUS UNITED STATES

U.S. Department of the Interior
Map



Alaskan OCS areas of leasing potential

Source: U.S. Geological Survey January 1980

U.S. Department of the Interior Map

OFFSHORE MISSION CATEGORY: ENERGY--OTEC

1. Mission of operating system: Electric energy production via OTEC conversion.

2. General Description of Mission:

Generate electric power from a renewable geophysical resource present in the sea, by utilizing ocean temperature differences to cause a fluid such as ammonia to evaporate and force the rotation of turbine attached to an electric generator.

3. Historical Development:

While experiments with the concept of OTEC power generation are relatively recent and are only now beginning to capture the attention of the popular press in place of some more conspicuous ideas such as wind, wave or tidal power, the notion is far from new. It was first articulated by the French physicist, Arsene d'Arsonval, in 1881. One of the reasons for the emergence of OTEC as a major alternative energy source is that the oceans act as a natural collector and storage mechanism for thermal energy derived from solar radiation. Because the ocean thermal resource is steady day and night OTEC electricity can be produced day and night to provide a "baseline" electric plant. OTEC power is one of the few solar energy options that will provide a baseline source of electricity. Planners and experimenters are only now beginning to appreciate the fact that OTEC costs or practically producing electricity can be best comparied to other baseline sources, of which coal, oil or nuclear power plans are the most likely alternative. For a variety of reasons, especially though because OTEC is one of the few baseline sources that is truely re-newable and lacks the safety issues surrounding nuclear power, it is emerging as a very attractive potential source of energy.

As an appealing potential source of substantial amounts of electricity, OTEC

technology is presently being examined to establish whether or not it is practical from the perspectives of technical, economic, and environmental matters. As is the case with the other major renewable energy options, they key questions about OTEC is the relative cost projected for that source compared to the cost of other alternative renewable sources and the rising cost of electric energy from depletable energy sources.

The first reported studies utilizing OTEC were conducted off Cuba in 1930. Experiments since were directed toward perfecting the conversion process. Studies since 1970 have been shifted toward finding cost-effective solutions to those technical process.

4. Level of Activity/Current Usage:

While there are presently optimized commercial OTEC systems in operation, the source is being developed in separate programs by the governments of France, Japan and the U.S., by a European industrial consortium known as EUROCEAN, and another industrial consortium operating in conjunction with the State of Hawaii. When compared to the U.S. government's OTEC program, which was funded at 38 million for FY 1979, all of the others are rather modest.

Extensive at sea testing of OTEC units or components has been underway for several years in the Gulf of Mexico and off Hawaii. Mini-OTEC, a barge mounted 50-kilowatt electric OTEC plant is the best known project. It is testing key power system components while generating 10 kilowatts of net power. The results of these experiments will be proprietary to the consortium of Lockheed, Alfa-Laval, Dillingham and the State of Hawaii who are underwriting the project.

5. Projected Use, Trends and Technological Forecasts:

There are presently two major OTEC systems in experimental development:

- Open-cycle systems within which sea water is used as the working fluid so that the condensate need not be returned to the evaporator.

- Closed-cycle systems using another medium (i.e., ammonia) as the working fluid within which it must be returned to the evaporator.

While most researchers feel that both open and closed systems have promise of commercial application, open systems are considered to be several years behind closed system technical development. Both have cost and technical difficulties to overcome. Open systems, because they must harness energy in low pressure steam need large turbines and degasifiers, which are fairly expensive. Closed cycle systems need very efficient heat exchangers which must be protected from corrosion and biofouling. Such protection may be very expensive so that heat exchangers may represent half the capital cost of a closed system OTEC plant.

The capital cost of OTEC power production will determine how competitive this kind of electricity is and how extensively it will be used. Since OTEC does not require fuel for plant operation, the major cost involved is the amoritization of the capital investment. DOE estimates the annual operation and maintenance costs of an OTEC plant platform or ship at 1% of the capital investment. Given current projections, estimated costs of producing electricity in an OTEC plant will be comparable to the costs of other baseline power sources such as coal or nuclear projected for the years 1990-2000.

Because it is assumed that OTEC plants will be constructed using standard modules, the costs of the first ones will be more than those of later units, meaning, of course, initially higher energy costs. Fortunately, markets will exist for this first electrically generated by OTEC plants: Tropical or sub-tropical islands such as Hawaii and Puerto Rico, where most of the power is now generated by expensive oil and plant-to-shore transmission lines can be fairly

short. DOE projects that OTEC plants will cost competitive for those islands by 1990.

Although such direct energy transmission to shore is the most nearly ready commercial application of OTEC, many researchers felt that given the relatively few areas of the U.S. where OTEC can be used, and given the fairly long transmission lines which will be needed on, for example the gulf coast (where plants would have to be located 120-140 miles from the using city), that the greatest long term use of OTEC will be for the manufacture of energy intensive products on industrial complexes sited around the facility.

6. Current and Forecasted Geographical Locations:

Because OTEC power plants need at least a 20 degree difference in water temperature, given current and forecasted technology, such electric generation is limited to tropical or sub-tropical waters. There are few U.S. locations that meet the requirements. These are principally the Gulf of Mexico, Hawaii, Puerto Rico and the American Virgin Islands.

It is suggested that eventually OTEC power can be generated for Tampa, New Orleans and Brownsville on the Gulf, all the Hawaiian Islands and Puerto Rico. Another possibility, although there are legal and jurisdictional problems, is the siting of an American industrial complex around an OTEC plant in the Carribean. Experts who have studied the matter believe that OTEC will become a major source of power for Hawaii and Puerto Rico.

Because of the location of the world ocean thermal resource, however, OTEC power plants will tend to be more available to the developing countries termed collectively the "third world".

7. Onshore Impacts:
   a. Cheaper or more plentiful electricity.
   b. Improved employment prospects.
   c. On air quality.
   d. On social and economic infrastructures
   e. On planning and management for other OCS/near shore uses.

8. Primary motivation factors/barriers/obviating factors:

Motivating Factors	Barriers	Obviating Factors
Demand for electricity growing	High capital costs	Suitable substitute
Need for renewable source of electricity	Geophysical requirements	Substitute consuming systems replace electricity or reduce demand
OTEC is one of few "baseline" renewable sources	Uncertainty of jurisdiction since some ideal OTEC locations are in international waters	Overriding loss of socioeconomic or political stability
Electricity central to lifestyle, economic system	Technical problems to increase cost efficiency to be overcome	
Increasing technical capacity to tap OTEC potential	Environmental risks because of thermal plum if too many OTEC plants operate too close together	
As other sources of electricty go up in cost, OTEC is becoming cost competitive to baseline plants	Environmental risks of industrial complex sited around OTEC plant	
Much safer than nuclear	No federal incentives yet in place for commercial development	
	Lack of proven technical reliability and performance	

9. Development Process:

What the development process for licensing and operating OTEC power plants offshore will be is unclear. Precedent suggests that such process will follow the same regulatory and economic feasibility steps as present OCS OSS and so follow the Growth Model presented in Chapter 11.

10. Forecasts:

10. Forecasts	1990-1995	1995-2000	2000-2005
Demand for electricity dramatically reduced	L	L	L
Electric use declines proportionately but grows absolutely	H	H	H
OTEC plants provide a high percentage of total U.S. electricity	L	L	L
Industrial platforms for the manufacture of energy intensive products sited around OTEC plants	L	L	L
2000,000 MWe or mre produced OTEC plants for mainland U.S. on Gulf of Mexico	L	L	L
Commercial OTEC power plants in the 100-400 MWe range provide electricity to some near-shore Gulf Coast urban areas	L	L	M
Commercial OTEC power plants in the 100-400 MWe range provide electricity to Hawaii or Puerto Rico	M	M	H

OFFSHORE MISSION CATEGORY: ENERGY--OFFSHORE WIND SYSTEMS

1. Mission of Operating System:

Electric energy production via tapping the energy in ocean wind currents.

2. General Description of Mission:

Generate electric power from a renewable geophysical resource present in the wind by utilizing some type of windmill to force the rotation of a turbine attached to an electric generator.

3. Historical Development:

Wind energy conversion systems are among the oldest MECHANICAL energy systems used by man. Interest has been rekindled today in wind systems by the environment movement. This is so because unlike most present sources of electricity and most of the alternative systems under feasability study, wind energy systems produce no by-products with the potentially for creating air, water, or thermal pollution. Also, as a by-product of electrolysis, a wind energy conversion system anchored to the ocean floor generating 49 billion kilowatt-hours per year of electricty could deliver 5 billion gallons of pure drinking water and 35.6 billion pounds of pure gaseous oxygen--all at no extra cost.

The major problem with wind energy conversion systems is that they are--unlike other alternative systems--not baseline systems. That is they are dependent on the vicissitudes of wind currents for their power production. Therefore, they are often mentioned for development in tandum with solar systems.

4. Level of Activity/Current Use:

There are, at present, no active wind energy conversion systems in place offshore or onshore. In Europe, however, Sweden and Norway have plans to establish

offshore wind energy facilities. The Norwegian program calls for 180 wind conversion units to be placed on 18 groups of 10 platforms each. Such an installation would be capable of generating 900 megawatts. Technical problems and construction costs have dictated that the installation can be placed in a maximum water depth of 10 meters.

There are no active plans, beyond small experimental programs, to install wind energy conversion systems in American waters.

5. Projected Use, Trends, and Technological Forecasts:

Offshore wind energy conversion systems presently face problems similar to those faced by the offshore oil industry in the 1940's. Many technical and economic problems remain to be solved, but the amount of energy which could be captured by the offshore wind resource is innumerous. A 1972 National Science Foundation study reported that with maxium effort installations for wind energy conversion systems placed at favorable sites along the U.S. shore line and the Great Lakes could produce more than 1.3 million kilowatt-hours of electricity per-year by 2000.

There are two major drawbacks. First, wind-produced electricity is very expensive because of very high construction costs. Also, as pointed out in Section 3, it takes a relatively large number of windmills to produce commercial quantities of electricity, which would result in large use of conflicts and greater dangerous navigation problems.

Also, to be most efficient, at least some systems should be placed fairly far out on the OCS, which raises many legal-political questions. The outcome of the question of national jurisdiction being considered at the United Nations Conference on Law of the Sea will strongly influence the scope of any future wind conversion program. Other serious question remain as well: commercial fishing conflicts, shipping lanes, recreational/aesthetic matters, offshore oil production and others.

The major factor influencing wind conversion may become an environmental one: since it is totally "clean", many environmentalists contend that it is one of the best long range solutions to the energy problem. This is particularly so to anti-nuclear proponents afraid of nuclear safety and sensitive to to the question of thermal pollution. If a major decision is made to "save" the environment, a major developmental emphasis is likely to be given to wind conversion system.

Data currently available indicates only one formal proposal for an American offshore ocean wind conversion system. This is a massive installation envisioned to serve the entire Northeast. Another promising U.S. OCS location is a vast and powerful wind field along the Aleutian chain and the South Coast of Alaska. Some experts feel that these winds are strong enough to justify an energy product sent to the lower 48 states that would still be economical. The Northeast wind conversion project calls for thousands of small windmills floating like buoys and hundreds of larger ones placed on platforms. In 1970 the project would have cost an estimated 43 million dollars. Most forecasters feel that the costs of such an installation would, in fact--even in 1970 dollars--be much more. Moreover, the unappealing thought of thousands of windmills inhibit much enthusiam for serious consideration of massive wind conversion systems at the present time.

6. Current and Forecasted Geographic Locations:

None at this time.

7. Onshore Impacts:

Because of the completely theoretical nature of any discussions about offshore wind conversion systems at this time, little consideration has been given to onshore impacts beyond the availability of renewable, clean sources of electricity. As pointed out in Section 5, there would inevitably be a reaction by the public to the effect on their beach-side views of the presence of wind conversion systems offshore.

8. Primary Motivation Factors/Barriers/Obviating Factors:

Motivating Factors	Barriers	Obviating Factors
Desire to find an electric energy source that can provide a high standard of living without degradation Need for renewable energy source Seen as safe "clean" alternative to nuclear power Attractive because wind perceived as "fee"	Very high capital costs, particularly because it is not a "baseline" source Geophysical requirements make it an unstable source Uncertainty of jurisdiction would likely be in international waters to be most effective Many technical problems to be overcome Lack of proven technical reliability No federal incentives in place Very high potential for extreme conflicts	Commercial Environmental safe OTEC plants developed first Substitute consuming systems replace electricity or reduce demand Decision made to accept lower standard of living to save environment

9. Development Process:

Insufficient data to draw conclusion.

10. Forecasts:

Forecast	1990-1995	1995-2000	2000-2005
Experimental wind power conversion systems will be established in selected locations	L	M	H
Commercial quantities of electricity will be generated by offshore wind wind conversion systems	L	L	L

OFFSHORE MISSION CATEGORY: Energy--Tidal Power Conversion Systems

1. Mission of Operating System:

Electric energy production via conversion of tidal energy.

2. Generate electric power from a renewable resource present in the sea by utilizing ocean tides to force the rotation of a turbine attached to an electric generator.

3. Historical Development:

Since at least the medieval period man has been trying to harness the power of tides. There are records documenting the existance of tidal mills in Europe from the 11th century. With the emergence of inexpensive hydroelectric power in the late 19th century, however, interest in tidal conversion diminished. Because of the shortage in energy being experienced by industrial nations, interest in this form of energy has been re-kindled.

This is because of tidal power represents a renewable resource, it needs no expensive fuel, generates no serious environmental pollution, land requirements are minimal, tidal plants are safe, reliable and fully capable of remaining on stream for a century. Tidal conversion also represents a "baseline" energy plant.

4. Level of Activity/Current Usage:

At present there are no active tidal power systems in operation within the U.S. The most successful use of tide power is at the La Rance estuary in France. That tidal plant is a 240 megawatt system which has met or exceeded all expectations since it went into operation in 1967. Its annual cost of operation comparies favorably with power obtained from conventional French hydro-electric systems.

5. Projected Use, Trends and Technological Forecasts:

Given present technology, operation of a tidal power conversion system requires a mean tidal range of more than 5 meters, if the operation can be economically feasable. There are only a number of worldwide locations which will meet that requirement. Although total tidal power potential represents a fairly small portion of world energy requirements, it could nevertheless save a rather significant amount of fossil fuels. For example, U.S. tidal power potential has been estimated to be 18,300 migawatts per year, which projects out to 30 million barrels of oil.

Technological improvements now being contemplated will change that equation, however. A new approach just articulated by DOE maybe able to operate in a tidal range of 2 meters and be built of relatively inexpensive, flexible light weight materials. If this concept is workable, it could mean that tidal power conversion systems will become practicable in many more areas worldwide and within the U.S.

Current systems are built around a ridged, traditional dam. Not only is this structure expensive to construct, but it closes the area to navigation. The new system, developed by Alexander Gorlov of Northeastern University uses a thin plastic barrier--termed a "water sail" to replace the conventional dam. Under the Gorlov concept the water sail could be dropped and pulled to one side, allowiing shipment movement into the tidal area.

The DOE has awarded Gorlov a contract to test the feasibility of his idea. If it is workable, it will revolutionize tidal power systems, at a time when, at least in the U.S. most planners are pessimistic about its practicality.

The South Korean government is putting a lot of money into developing the tidal power potential in two Korean estuaries. The French are considering building another tidal power conversion system, and the Canadian government

has earmarked 33 million dollars to develop the tidal potential of three areas in Quebec.

6. Current and Forecasted Geographical Locations:

Internationally, the areas that appear to hold the most potential are:

- o Bay of Fundy, Canada
- o Bay of Mount St. Michael, France
- o Gulf of Mezen, Soviet Union
- o Severn River, England
- o Walcott, Inlet, Australia
- o San Jose, Argentina
- o Asan Bay, South Korea

7. Onshore Impacts:

Insufficient data beyond generalizations of the positive impacts of more electric power.

8. Primary Motivation/Barriers/Obviating Factors:

Motivating Factors	Barriers	Obviating Factors
Growing demand for electricity	High capital costs	Suitable substitute of renewable baseline electricity found
Need for renewable sources of baseline plants	Strict geophysical requirements	Substitute consuming sytems replace electricity or reduce demand
Little or no environmental pollution	Technical problems to increase geographical locations must be over-	Development of another baseline, renewable, safe source of electricity first
Much safer than nuclear		
Proven technical reliability and performance	Few locations suitable in U.S.	

9. Development Process:

Probably similar to present system of licensing and operating conven-

· -al hydroelectric dam, with special provisions for navigation requirements included.

10. Forecasts:

Forecast	1990-1995	1995-2000	2000-2005
Without technological breakthrough, tidal conversion systems supplying commercial electricity to select U.S. areas	L	L	L
Experimental systems established in most promising areas for tidal conversion	L	M	L

OFFSHORE MISSION CATEGORY: ENERGY--CURRENT, WAVE, DEEPSEA PRESSURE, SALINITY GRADIENT, SEABED GEOTHERMAL AND BIO-CONVERSION ENERGY CONVERSION SYSTEMS

1. Mission of Operating system:

Electric energy production via tapping the energy in an ocean resource.

2. General Description of Mission:

Generate electric power from a geophysical or biological resource present in the ocean by utilizing a conversion system to force the rotation of a turbine attached to an electric generator.

3. Historical Development:

These six conversion systems are listed together because they are all at about the same level of development and, with the exception of bio-conversion techniques, show minimal potential for the time period of this study. And even the process that is the most advanced--open ocean farming of seaweeds for conversion to methane fuel-offers considerable hope for the future but is a long-term prospect. The premise behind all of these systems is that most of the energy in the oceans is bound in thermal and chemical forms.

Most of these forms of potential energy received little or no thought beyond an occasional interesting article in a professional journal until the attention of the scientific and planning communities was focused on alternative energy sources by the acknowledgement of an "energy crisis". Similarly, in the case of each of the systems, large quantities of energy would be available if economical ways to tap the respective resources can be found. Because other ocean resource conversion systems have a head start, these systems are very dependent on some key variables such as technical breakthroughs and the time frame for development of tidal power or OTEC. In the same vein, if the U.S. does make a formal decision to deemphasize development of the nuclear potential,

then these systems will receive more attention and funds.

4. Level of Activity/Current Uses:

There are no commercial conversion systems utilizing any of the systems presently in operation. All of the systems are undergoing at least small scale experimental testing. The systems undergoing the most systematic testing beyond the theoretical are: wave conversion, current conversion and salinity conversion. Biomass conversion is dependent not upon the technology of energy conversion, but upon seaweed farming, and so is covered in that chapter.

5. Projected Use, Trends and Technological Forecasts:

a) Current Conversion System

The major circulating ocean currents (gyres) are among the most powerful reservoirs of solar energy on earth. Current energy is created by a twofold intensification of direct sunlight: that conversion of direct solar heat into wind, and the conversion of the stress placed on a surface into wind driven ocean currents. The central mechanism behind most current conversion systems is some sort of two-stage rotor made up of counter-rotating turbines which are driven by an ocean current in the same manner that the wind turns a windmill. DOE is funding several studies to study technical issues involved in the various current conversion systems under development. Much of the basic research remains to be accomplished. There has been no agreement as to which of the proposed systems will be most efficient, what will be the optimum size of such facilities, how much electricity can actually be generated, nor any confirmation of engineering, economic or environmental specifications.

b) Wave Conversion Systems

Like the currents themselves, ocean waves are generated by atmospheric winds. The energy that results from that wind action against the surface is very effectively conserved until it reaches the coast. The concept of captur-

ing that potential energy is simple: relative motion between two or more elements that may be utilized to drive a turbine. While simple in theory, all of the work accomplished so far on wave conversion systems has been theoretical. Moreover, conservative estimates of the cost of electricity generated by wave conversion systems and delivered ashore, are more than ten times that of electricity generated by a conventional, onland power plant. While, of course, substantial improvement of that figure may be expected from a developmental program, as yet, it is too early to make any evaluation of the potential of wave power conversion systems for generating substantial amount of the U.S.'s electric needs. Other unknowns include not only the total power outlay and cost, but also such critical criteria as whether wave systems will be strong enough to survive in the open ocean, and capable of long term operation with a high degree of reliability.

c) Salinity Gradient Energy Conversion

This potential source of electric power is one of the most unusual, and one that received little notice until the late 1970's. Like wave power generation, the theory behind "salt power" is simple: There is a large osmotic pressure difference between fresh and salt water, particularly where large rivers flow into the ocean, if an economical way to utilize such salinity gradients could be found a completely untapped, but totally renewable, baseline source of electricity could be developed. Researchers feel that osmotic pressure equivalent to a 200 meter waterfall exists at the mouth of every river in the world.

Two theoretical methods are under investigation to utilize "salt power": reverse electrodialysis stack two types of charged permeable membranes are used. The biggest problem with this method so far is that the membranes are prohibitively expensive for a plant big enough to generate commercial volumes of electricity. Pressure related osmosis uses pumps, pressure chambers, and turbines to release osmotic power.

At present, research has not progressed beyond the point of determining that it is certainly possible to produce electricity from salinity gradients, but cost is the critical factor (as will be environmental impacts, which, in the laboratory, are totally unknown). The pressure related osmosis method is so theoretical that no cost estimates have even been attempted, and it is felt that membrane technology would have to improve by at least a factor of 100 in the cost of membranes before concept of reverse electrodialysis is worth even considering.

d) Geothermal and Deepsea Pressure Conversion Systems

These systems are even less well understood in terms of technical and economic feasibility than the others already discussed. The few number of appropriate deepsea trenches and their distance from the U.S. almost precludes serious U.S. development of this source in the foreseeable future, and the cost efficiencies, the nonrenewable nature of geothermal deposits, unanswered environmental questions and the much greater appeal of other energy sources, mitigate against development of geothermal energy conversion systems.

6. Current and Forecasted Geographical Locations:

There are no present locations and development has not reached the stage to determine future geographical locations, although obviously ocean-current electrical power generation will be located in the worlds major ocean currents. For the U.S. this most likely means the Gulf Stream.

7. Onshore Impacts:

Beyond the generalized aspects of construction activities and an improved or new source of electricity, completely unknown.

8. Primary Motivation/Barriers/Obviating Factors:

Motivating Factors	Barriers	Obviating Factors
Demand for electricty growing	High capital costs	Successful development of another renewable source of electricity
Need for alternative sources	Geophysical requirements	
Increasing technical capacity	Theories not completely proved	
Feeling that it is not good to concentrate on only one or two alternative sources	Environmental risks because too many "unknowns"	
	Lack of proven operational potential	
	Lack of proven technical capacity	

9. Development Process:

Insufficient data.

10. Forecasts:

Forecasts	1990-1995	1995-2000	2000-2005
Commercial current conversion system operates	L	L	L
Commercial wave conversion systems operates	L	L	L
Commercial deepsea pressure conversion system operates	L	L	L
Commercial salinity gradient conversion system operates	L	L	L
Commercial seabed geothermal conversion system operates	L	L	L
Theories for all the above developed to the point that at sea experiments put into operation	L	L	M

OFFSHORE MISSION CATEGORY: ENERGY—FLOATING NUCLEAR AND CONVENTIONAL POWER PLANTS

1. Mission of Operating System:

Electric energy production.

2. General Description of Mission:

Generate electric power by utilizing nuclear or conventional means to force the rotation of an electric generator.

3. Historical Developmental:

The commitment of the United States to the development of nuclear power was first expressed in the Atomic Energy Act of 1954, which created the Atomic Energy Commission. Given the fact that the supply of fossel fuels were declining and the demand for energy was rising, it was predicted that nuclear reactors would supply the major portion of America's electricity by the 1990's, and were the best long term solution to the finite quantity of other "renewable" energy sources. At the beginning of the 1980's, nuclear plants are supplying 10-12 percent of the nation's energy needs, and it is predicted that they may supply 50 percent by the year 2000. Using October 1979 as a base line, there are 73 nuclear, onland reactors in the U.S. with a capacity of 52,273 megawatts. But, for all the early optimism, the promise of onshore generations of nuclear power has fallen well short of expectations and is encountering growing public opposition. This is largely because of the extreme potential for environmental pollution posed by nuclear power plants, and the very real danger of catastrophic nuclear accidents which hangs over all such installations since the near disaster at Three Mile Island.

Even though there are a number of different types of nuclear technology that may be harnessed to produce electricity, the important point is that they share basically the same pollution problems. These problems include thermal pollution,

perimeter contamination, and the risk of major accidents. The pollution and safety concerns lead to common concerns involved in the siting of nuclear power plans. Many, if not most of the same public concerns are involved in the siting of conventional power plants, which are not popular neighbors anywhere.

There are critical factors that limit the siting and building of power plants on land: a power plant, particularly a nuclear plant, may require 500 acres of land and a million gallons of water for cooling per minute. Clearly, there are geographical limits for power site selection on the mainland U.S. By the late 1960's many of the best possible sites had already been put into use, and environmental and community groups began pressure against utilization of those sites that remained. This was so for both conventional and nuclear facilities, even though much publicity was focused on the antinuclear factions.

One "common denominator" solution to the siting of power plans has been vigorous interest in placing them offshore. Offshore siting, while having the potential to cause some of the same problems as onshore siting, does resolve many of the difficulties, and also introduces some positive advantages.

The idea of offshore siting for nuclear or conventional power plants was first proposed in 1969, and has been researched with increasing intensity since then. Offshore siting is easily within the current state-of-the-art.

4. Level of Activity/Current Use:

There are no active offshore nuclear or conventional power plants, although a number are in the planning stage.

5. Projected Use, Trends, and Technological Forecasts:

Whether there are short-term energy shortages, traditional fossil fuels will be exhausted at some time in the future. Despite the current public opposition to proposed nuclear power plants, nuclear power has the potential for at least partially solving predicted energy shortages in the

next two decades. This is so regardless of exploitation of other potential energy sources; development of nuclear is simply further ahead than development of other alternative sources, and despite the risks, nuclear is basically pollution free, inexpensive, and easily obtainable.

Offshore nuclear plants, either sited on artificial islands or floating, consist of existing technologies and, according to most studies are already cost competitive to the same facility constructed on land. Westinghouse, and Tenneco have created a joint subsidiary, Offshore Power Systems, to combine their skills in nuclear plant and ship-platform construction to develop offshore energy systems. In 1974 Offshore Power Systems contracted with Public Service Electric and Gas of New Jersey for four 1,150 MW reactors. Two of the reactors are to be used at the Atlantic Generating Station on a site located several miles offshore Atlantic City.

Offshore Power Systems has established a manufacturing facility in Florida to construct standard offshore power plant models. This firm has a cost advantage over on land systems since the design is not affected by different site topographies. The design and layout of each offshore plant is uniform and a central manufacturing facility provides other economies because no on-site construction team is required. That method of construction also leads to several other advantages: standardization not only will reduce overall cost, but reduces potential errors; the production time necessary for plant construction also will decrease by several years.

Offshore conventional power plant siting is aslo being encouraged by the federal government. TRW is currently under contract to provide the federal government with a study of the feasibility of locating a coal-fired generating plant 12 miles offshore Los Angeles. The fuel would be an oil-based coal slurry delivered by underwater pipeline.

Other concepts call for solving the danger of LNG in crowded urban areas by construction offshore LNG fired conventional power plants. No formal plans have been developed for this idea, but several companies are believed to be studying the technical problems which would limit such a plant's feasibility. As is the case with nuclear generating plant, coal fired offshore power plants are believed to be cost comparable to land sited plants.

6. Current and Forecast Geographic Locations:

Since there are still serious safety, environmental and public acceptance problems to locating offshore power plants in or near busy coastal areas, it is impossible to give a timetable for when any of the proposed plant will go onstream. The only current factors limiting the geographical location of nuclear plants is that they must be an area without serious seismatic activity and given current technology must be sited in at least 45-75 meters of water. Conventional plants share the same limitations.

Because of the massive projected needs of the east coast of electric power by the end of this century, most current plans under consideration call for offshore power locations on the Atlantic OCS.

7. Onshore Impacts:

Basically similar to other mission, this is the most controversial element in offshore siting of power plants. While few question the positive benefits of an assured, low cost source of electric energy for contiguous onshore areas, many question whether the environmental risks of such plants, particularly nuclear plants, outweigh any potential benefits. Certainly, that is a valid point. For example, if current projections for energy demand hold up, the goal which was stated in the 1960's of having 70-90 percent of the east coasts electricity generated by nuclear plants onshore or offshore, is not environmentally feasible. Generating capacity to fill that need would require nuclear plant located

at approximately 5 mile intervals along the Northeast's coast. Because of the problem of thermal pollution such a siting strategy is simply not an option. It would cause serious environmental and navigational hazards.

The point is that risks and benefits will have to be very careful weighed. Moreover,the potential of offshore electric generation has probably been over stated because advocates have looked at onshore impacts and environmental risks in terms of each individual facility, only the opponents have argued for cumulative impacts. In short, despite the real potential--particularly at short-term at the turn of the century potential--represented by offshore nuclear plants, they likely do not represent a long term solution.

8. Primary Motivating Factors/Barriers/Obviating Factors

Motivating Factors	Barriers	Obviating Factors
Demand for electricity growing	High capital costs	Suitable substitute source to fill demand
Low cost source with the technology already developed	Geophysical requirements and potential for pollution risks of accidents leave no margin for error	Substitute consuming systems to reduce demand
"Baseline source"	Technology/plants not as safe as proponents claim	Public decision that risks outweigh benefits
Electricity central to life style, economic system	Uncertainty of jurisdiction since best locations in international waters	International law precludes siting in international waters
Proven technology already in place, so no developmental lead time	Anti-trust concept of natural monopoly may inhabit capital investment	Overriding loss of sub-economic political stability
Offshore siting removes many on land siting problems and lowers cost	Public resistance	
	Catastrophic results of mistake	
Offshore siting (if more than 5 miles out) environmentally safer than on land siting	Regulatory ambiguities, requirements resulting in long lead time	

Cont'd

Motivating Factors	Barriers	Obviating Factors
Technology/plants safer than opponents claim	Conflicting uses Aesthetic Considerations	

9. Development Process:

While in general, the development process for offshore nuclear and convential power plans will follow the steps given in Chapter 11, there are some ambiguous areas. Domestically, in addition to the agencies with OCS responsibility identified in the growth model, offshore nuclear power plans will be regulated by the Nuclear Regulatory Commission, which will license and regulate the construction and operations of the plant. However, one problem is that no existing legislation covers a floating power plant should it be placed beyond U.S. territorial limits on the OCS. Existing international law has not decided the jurisdictional questions involved in siting "Artifical Islands" outside territorial waters. This is because, as already pointed out, environmental, technical, and geologic considerations limits the sites suitable for offshore power plant construction in U.S. territorial waters.

10. Forecasts:

Forecast	1990-1995	1995-2000	2000-2005
Environmental and safety questions will combine with pressure from environmentalist groups to dramatically slow development of offshore electric generating plants	H	H	H
The U.S. will abandon attempts to develop and exploit the offshore nuclear potential	L	M	M
The absence of feasible alternative electricity sources will keep planners interested in the offshore potential	H	H	H
Offshore nuclear plants and conventional plants will be economically feasible and cost competitive with onshore electric production, but for social and political reasons will not be built	M	H	H
A major number of offshore power plants will be in operation	L	L	L
A small number of offshore power plants will operate for select, high demand urban areas	L	L	M
A substitute source of electric energy will be developed for commerical application before the environmental and political issues and questions surrounding offshore siting are resolved	L	L	M

APPENDIX TO CHAPTER 3 OF VOLUME II -- NATIONAL SECURITY

OFFSHORE STRUCTURE MISSION CATEGORY: Military and Space

1. Mission of Operating System: Weapon Target and Space Program Range Structure

2. General Description of Mission: Instrumented bottom-mouthed structure placed with some precision along a missile or gunnery range; purpose is to track missiles or projectiles in flight toward a target for training or developmental purposes.

These structures are erected in a small number of geographical locations off east and west coasts of the U.S. and in the Hawaiian Islands. Their interaction with other than military operations is minimal. They are placed to be out of the way of traffic channels and only infrequently interact with commercial fishing interests. They are maintained and protected by the military service having cognizance over the range. They are unmanned except for brief periods during test or practice operations.

3. Historical Development: The growth of the population of range structures has accompanied the growth of guided and ballistic missiles in our military arsenals since World War II. Range growth has lagged only slightly behind missile growth and has stabilized at one major missile range on each coast with other lesser ranges along each coast and in Hawaii.

4. Level of Activity and Current Usage: Level of activity varies with the defense budget, but remains fairly stable from year-to-year. Current usage is such as to offer minimum interference with other uses of the ocean areas, but is of such priority that any encroachment into the space would probably encounter strong resistance from the military services.

5. Projected Use, Trends, and Technological Forecasts: For the remainder of the century usage of these structures will increase gradually as weapons technology advances and other less sophisticated means of tracking weapons flights become less adequate. Technological advances in instrumentation will lead to increasingly advanced technologies in use in these structures, but spill-over

into nonmilitary uses is not foreseen.

6. Current and Forecast Geographical Locations. No trend is foreseen to increase the number of ranges, but expansion of ranges is likely. However, since these ranges are placed geographically to offer least interference with traffic and other economic activities, this expansion should offer minimum problems to nonmilitary users.

7. Onshore Impacts: The onshore impact of these structures is minimal. During their construction there may be some local temporary effects, but otherwise they perform their missions in an unobtrusive manner as far as the shore population is concerned.

These structures constitute an important element of a major communications network in military and space systems; thus damage to them would be regarded as important. Should antisocial activities involve destructive action against them, the U.S. military establishment would become involved quickly.

They invoke virtually no clamor from the environmentalists.

8. Primary Motivating Factors/Barriers/Obviating Factors: The principal motivating factor toward the growth of these structures is the advancing technology of military weapons technology and space technology. To the extent that competition with the USSR is a driving force on the U.S., it operates to continue the advances in technology that lead to increased numbers and complexity of these offshore range structures.

On the other hand, the complex of range structures now in existence was established during the '60s and experienced rapid growth during that time; growth from now through the end of the century may be considerably slower than during the '60s. Significant expansion of the geographic areas in which these structures are built is not expected. Cutbacks in Defense or Space budgets could bring all further expansion to a halt.

The only obviating factors are: (1) nuclear holocaust, or (2) near-complete peaceful reconciliation among the great powers.

9. Development Process--Specific Application of Growth Model: For the purposes of this project the growth process of these structures is not significant.

10. Forecasts: Military and space range structures will continue to be constructed and the technologies in use by them will continue to advance. However, the number of structures is unlikely to increase significantly by the end of the time period of this project, and neither is the relative importance of these structures in the OSS universe likely to increase significantly.

OFFSHORE STRUCTURE MISSION CATEGORY: Military and Space

1. Mission of Operating System: Acoustic Surveillance of Broad Ocean Areas

2. General Description of Mission: Large bottom-mounted hydrophone arrays placed in selected locations in both the Atlantic and Pacific. Each array contains a number of hydrophones spaced with several miles between them in such a way as to permit triangulation of detected acoustic signals from potential adversary submarines and other draft. These signals are analyzed and processed through a central station on each coast of the U.S. When the system is operating at full effectiveness, all potential enemy submarines are kept under complete surveillance whenever they are within several thousand miles of U.S. territory. The system is highly classified, so technological advances and troublesome problems in operating the systems are not known.

3. Historical Development: Technical feasibility was established during or immediately after WW II, and installations began soon thereafter. Coverage is estimated to be side at this time, but security barriers inhibit detailed knowledge.

4. Level of Activity and Current Usage: Estimated to be significant, but not known.

5. Projected Use, Trends, and Technological Forecasts: It is estimated that in the past ten years there have been no technological breakthroughs sufficiently important to lead to either a drastic increase or decrease in the use and coverage of the U.S. Navy's long range acoustic listening systems mounted on the ocean floor (called "SOSUS" units); it is also estimated that the acoustic properties of the oceans are sufficiently understood that a quantum jump in use or coverage is unlikely during the period of this project.

6. Current and Forecast Geographical Locations: Each SOSUS installation is expensive, so budget limitations have prevented as full coverage as the Defense Department would like; as funds become available gradual increase in the number of arrays and in geographic coverage will occur.

7. Onshore Impacts: Onshore impacts of SOSUS units outside the Defense Department is minimal. Their security classification is so high that every attempt is made by military units concerned to maintain a very low profile and impact.

8. Primary Motivating Factors/Barriers/Obviating Factors: The impenetrability of the oceans beneath the surface is the principal motivating factor toward increasing use of SOSUS. As long as mutual defensive postures, U.S. vis-a-vis USSR, exist, the motivation for increased SOSUS coverage will persist. The Defense budget is the principal barrier. The only obviating factor would be a technological breakthrough in reducing the opacity of sea water to some non-acoustic form of radiation.

9. Development Process--Specific Application of Growth Models: For the purpose of this project the growth processes of these units is not significant.

10. Forecasts: Military need for SOSUS units will persist throughout the time period of th is project, and will result in a gradual, but slow increases in the number of units installed and in the geographic coverage.

OOFFSHORE STRUCTURE MISSION CATEGORY: Military and Space

1. Mission of Operating System: Readiness and launch positions for ICBM weapons

2. General Description of Mission: Massive tubal structures buried beneath the seabed and containing ICBM weapons ready for launch; none yet in place as far as is known; none in planning stages as far as is known; however, security provisions would probably prevent knowledge of any planning until well along into the planning process.

3. Historical Development: None

4. Level of Activity and Current Usage: None

5. Projected Use, Trends, and Technological Forecasts: The probability of significant numbers of installations before the end of the century is not high; however, the decision to initiate such a weapons complex can be made by a highly centralized authority--the President in consultation with the Secretary of Defense and Joint Chiefs of Staff--so changes in international tension could lead to a sudden change in the outlook.

6. Current and Forecast Geographical Locations: None currently; forecast locations on the OCS in the Atlantic as the highest probability location, followed by OCS in the Pacific, including the Hawaiian Islands.

7. Onshore Impacts: Although the very presence of these installations would be kept as secret as possible, the effect of their existence would be great in a number of dimensions--locally in terms of logistics support, the C^3 network, operational support, etc., and nationally in terms of political, economic, and military factors.

8. Primary Motivating Factors/Barriers/Obviating Factors: Technological advances that render these seabed silos militarily effective and economically feasible, and international trends that render them desirable constitute the principal motivating factors. Prolonged and credible detente, on the other hand, would

obviate their need. Enormous costs and resource requirements constitute the barriers.

9. Development Process--Specific Application of Growth Model: Not applicable.

10. Forecasts: These seabed silos will not appear in more than planning stages before the end of the century.

OFFSHORE STRUCTURE MISSION CATEGORY: Military and Space

1. Mission of Operating System: Safe storage of nuclear waste products

2. General Description of Mission: Deep holes drilled into the seabed into which nuclear waste products are injected. Not strictly a military mission, but likely to be placed under the aegis of the Defense Department for security reasons.

3. Historical Development: None

4. Level of Activity and Current Usage: None

5. Projected Use, Trends and Technological Forecasts: Although these storage means are the subject of discussion, and have been for some time, and although they would in fact solve some of the nuclear waste problem the expense of drilling to the depths required, and the unproven technical feasibility of guaranteeing absolute safety are likely to militate against action for many years.

6. Current and Forecast Geographical Locations: None

7. Onshore Impacts: NA

8. Development Process--Specific Application of Growth Model: Not applicable

9. Forecast: Unlikely to be started before the end of the century.

APPENDIX TO CHAPTER 4 OF VOLUME II -- FOOD HARVESTING/PRODUCTION

OFFSHORE MISSION CATEGORY: Food Harvesting/Production

1. Mission of Operating System: Fisheries Management, Husbandry

2. General Description of Mission:

Extract living animal resources from the ocean in commercial quanitities

3 Historical Development:

Fishing was the first and for many years the world's only true ocean industry. Commercial fishing, as a major industry, developed in the fifteenth and sixteenth centuries when the discovery of rich northern Atlantic distant banks and coasts impelled the more adventurous into the deep ocean to exploit herring and cod. The Atlantic commercial fisheries quicky became a major source of food for Europe, and deep sea fishing became a major sector of most national economies. Small scale coastal fishing, often at a near subsistence level, remained important to many local economies until well into the twentieth century. During the twentieth century, this way of life, which had taken thousands of years to evolve, was largely extinguished in favor of newer and more profitable techniques.

Like most major industries, the commercial fishing industry's development has been highly dependent upon technology. The introduction of first steam and the diesel propulsion for fishing craft accelerated the exploitation of fishing resources farther and farther from a ship's homeland. After the second world war, the economics of the industry were further improved by a series of technological innovations: modern refrigeration, electronic navigational aids and acoustic devices for locating fish. Larger, more efficient ships, often with in-board processing plants, ranging very farm from their home ports became the rule by the 1960's for the fleet's of the most advanced fishing nations.

The use of such highly sophisticated vessels by fishing fleets had a revolutionary impact. The coastal, subsistence-fighting economies of a number of less developed countries (LDC's) were completely destroyed because of competition from imported, inexpensive frozen fish; but, even the internal commercial fisheries of some advanced nations were affected. The large, very efficient fleets supported by Japan and the U.S.S.R. proved to be difficult competition for the smaller ships used by Americans off the Northeast U.S. coast. Moreover, the introduction of large, efficient vessels taking very large numbers of catches at one time rapidly over fished some of the most fertile Atlantic and Pacific areas, as well as over fishing and depleting the stocks of some species such as cod.

The traditional freedom of the seas that existed in world governance from at least the seventeenth century had supported the right of foreign vessels to freely fish offshore waters outside a limited territorial zone. That tradition had been supported by two main bases: the resources of the oceans seemed unlimited, at least in relationship to then current technology: and, the most powerful maritime states after defeat of the sixteenth century Spanish attempt to impose sovereignty over the Atlantic (in historical order, Holland, England, the U.S.) had a vested interest in maintaining "freedom of the seas" because they wanted free trade and easy assess to world markets. Both of these bases have been eroded drastically in recent years.

The collapse of the stocks of many important species, the new importance of non-living ocean resources, and the discovery of environmental concerns have all shown that the sea's resources are not unlimited. Most countries now feel that there is an important need to protect to protect their own coastal resources if they are to reach the full potential of their economic and social systems. That trend resulted in pressures to extend the limits of jurisdiction excercised by coastal states over fisheries. Many coastal states passed legislation extending

such jurisdiction, a fact recognized by the Law of the Sea Conference which is ready to provide guidelines that in addition to a territorial sea out to 12 miles, each nation has an exclusive economic zone out 200 miles in which the coastal state will have dominant authority over and responsibility for fisheries.

With this new legal framework, world fishery management is entering a new age. The future of many of the highly capitalized fishing fleets is in serious doubt in the emerging new age. This is so because an integral part of the new system for most nations in regulations limiting the size of the catch within their economic zone. Besides protecting the stocks of fish that remain, an important component to the developing management system for fisheries is the equivalent of on-land husbandry. The popular term for the concept is fish farming, or aquaculture.

In terms of a conceptual design for development of marine animal resoures as a food source, programs for "fish farming" are analogous to on-land evolution of animal husbandry. Human societies first exploited animal and plant resources from their on-land environment by hunting and gathering. The next developmental step is often a herding or ranching stage. In this stage the perferred food animal is semi-domesticated and guided or followed in grazing over its more or less natural range. The range is not completely natural because some limited burning, deforestation and predator control is exercised. Farming is the next, and most sophisticated form of developmental husbandry. In that state the farmer exercises a high degree of control over the environment, developing vegetation and protecting animals by providing food, shelter and relative freedom from predators, and controls the animal itself by selective breeding.

For almost all of human history, fisheries have remained at the hunting gathering stage of development. The herding, or ranching stage is the mode of culture that is most broadly promising for marine animal husbandry. While of

extreme importance to the overall marine economy and global supply fisheries management--whether hunting and gathering or ranching--will be of little impact on the subject of this report. Not only will full development come well after tne time frame, but few offshore structures will be involved in the first generation ranching efforts.

4. Level of Activity/Current Usage

In the U.S., marine animal husbandry is the subject of much experimentation for the U.S. Most present commercial applications, however, involve fresh water pond "growing" of fresh water species such as trout or catfish. There are relatively few commercial salt water facilities, and those require a minimum of offshore facilities.

The only salt water species cultured in commercial quantity in the U.S. are salmon. Salmon are cultured for food in three states and "ranched" (on a rather small scale) in three others. At present only pan-sized salmon are grown and sold to the restaurant trade.

There also is one commercial marine shrimp culturing farm in the U.S. This installation is located in Florida. It is established in a tidal estuary which is protected by mesh fences across the opening to the sea.

5. Projected Use, Trends and Technolgical Forecasts

Commercial marine husbandry has many obstacles to overcome. The present systems used in the U.S. are very similar to conventional restocking programs. They also are rather expensive.

Projected use of marine husbandry hinges upon its economies in comparison to traditional hunting, gatherine of marine arnimals. For a variety of reasons, there is little indication in the literature that near-term, full-scale farming of salt water species will be developed. The ranching of

migratory species such as salmon, shad and smelt could become an important commercial activity. Present technology, largely developed and successfully used by the Japanese, is sufficient.

A ranching system at sea will consist of large raising and harvesting pens centered around the release of some chemical attractor to reinforce the fish's chemical memory. Such a system would possess a great advantage over traditional onshore ranching--an instinctive roundup. Most forecasters envision that species, such as smelt, offer the most economical return of sea ranching since they are much further down the food chain than salmon.

Shell fish culture also is seen as being an economical form of marine husbandry, since the yield per acre could approach 100 tons.

For the long term, there are predictions that marine husbandry can be combined efficiently with offshore structures built for other uses. That is, use offshore facilities designed for another mission to serve also as an artificial reef to attract animal life, or with holding and harvesting pens to serve as the center of a ranching operation. Such plans usually call for on-site processing of the "harvest."

While the first generation of at-sea ranches will involve few offshore structures, they will pose extreme use conflicts with commercial hunting fisheries and other offshore structures. Another problem, which is not discussed in any of the literature, also will result in use conflict. Effective ranching is dependent upon predator control. In any culture system, control of predators also includes competitors in the food chain. So, even if the ranched species are protected from predators, which feed on the semidomesticated fish, they still will face problems caused by other animals in competition for the same food. The point is that some form of cooperative commercial

hunting fishery would be necessary in the area, hunting competitors in the food chain. However, any tampering with the food chain by removing a species from the ecosystem, can have long term and unanticipated results. Environmental concerns could dictate that a ranch could have negative environmental impacts for certain areas and so not be permitted.

6. Current and Forecasted Geographical Locations

Current location for fish culture (raising fingerlings onshore and then placing them in offshore holding pans to grow to pan-size) are located in Maine, Washington, and Oregon.

Salmon "ranches" are located in Alaska, Washington, and Oregon.

Shrimp are farmed commercially in Florida.

The first generation of sea ranches, since they will be dependent upon migratory species are predicted for the same general locations. Shellfish culture is possible in any coastal location. The gulf coast is a potential location for mussels and shrimp culture, as is Southern California.

7. Onshore Impacts

- Employment
- Increased food supply
- Possible use conflicts
- Possible impacts on the food chain

8. Primary Motivation Factors/Barriers/Obviating Facors

Motivating Factors	Barriers	Obviating Factors
Demand for sea food World "food problem"	Highly capitalized High risk	Replacement of sea-animal resources by complete dependence on onshore resources
Exhaustibility of fish stocks without restocking via "over fishing"	Further economic feasibility studies needed	Substitute protein and food sources developed

(Continued)

8. Primary Motivation Factors/Barriers/Obviating Factors (Continued)

Motivating Factors	Barriers	Obviating Factors
Opportunity to increase overall productivity of a U.S. industry	Uncertain federal, state and local regulatory status	
	Use conflicts	
Increase in absolute number of fish implies spin-off for commercial hunting industry and recreational fishing	Geophysical limitations	
	200-mile fishing zone will increase "hunt and gather" fishery production	

9. Development Process: Unclear, the central issue will be preemption of ocean or tidal space as private property for individual profit.

10.

Forecasts	1990-1995	1995-2000	2000-2005
Animal husbandry in marine environment is selected as a major source for seafood production	L	L	L
Consumer demand for animal seafood remains high	H	H	H
Extensive, complex marine husbandry facilities built, including permanent structures for processing facilities	L	L	L
Small number of ranches for migratory species established in selected locations	L	M	H
Fish farms established for non-migratory species	L	L	M
Farms established for shellfish & other expensive "luxury" marine animals	L	L	M
Zoned areas created for marine animal husbandry	L	M	H

OFFSHORE MISSION CATEGORY: Food Harvesting/Production

1. Mission of Operating System

Production or harvesting of plant life from the marine environment

2. General Description of Mission

Extract plant resources from the ocean in commercial quantities

3. Historical Development

Indigenous plants extracted from the sea--popularly called seaweeds--are now an important raw material for a number of industries and an important item in the diet of Orientals. While aware of the food value contained in seaweed, it has never been a staple food in Western countries. This is because enculturated Western tastes have not been attracted to what is viewed in those cultures as an exotic food. Plants from the sea have been harvested and cultivated by the Koreans and Japanese for centuries.

In contrast, seaweed has been used in the West as a food ingredient or for commercial byproducts since the 19th century. Little western harvesting or cultivation of seaweed took place, however, unti the second World War shut off Japan as a source of imports. During that conflict, commercial harvesting was begun in Southern California. The primary commercial use of seaweeds in American traditionally has been as a source of alginic acid. Fertilizers also have been produced from brown seaweed, and red seaweed is used in refining some American beers.

The industry experienced little growth for most of its history. There was little speculation about following the Asian example and turning to seaweed as a major food source until programs surfaced in the early 1960s to solve the world food problem. The cultivation of seaweed as a human food source, as a base for animal feed, for its commercial byproducts is now seen potentially as an important use of the sea. The biggest boost in developmental planning for

the cultivation of seaweed in American waters, however, has been the depletion of the earth's raw materials for energy conversion and modern interest in utilizing fermentation technology to produce fuels and other byproducts out of biomass. Farming of seaweed is seen as an important, perhaps the most important, long term source of biomass raw material for conversion systems.

Interest in increasing food production coupled with the use conflict between agricultural production and other on-land activities has resulted in experimentation to develop salt-resistant species of traditional food plants. The goal of this research is to use the sea in order to increase the amount of land in traditional food production.

4. Level of Activity/Current Usage

The level of experimental activity in the U.S. is quite high, but the commercial harvesting of seaweeds is still a rather small industry. The industry, particularly the harvesting of the plants for production of seaweed colloids, is experiencing a high annual growth rate. The principal areas of production are:

East Coast:

North Carolina
Florida

West Coast:

Southern California
Lower California

5. Projected Uses, Trends and Technological Forecasts

At present, kelp is seen as the seaweed with the most commercial application as a source for biomass. Present experimental programs are directed toward cultivating kelp on an artificial substrate in the oceans and converting it by biochemical processes into liquid fuels as well as other byproducts. These will include a range of food products. The first generation technology

for the processes, particularly fermentation processing, is developed for on-land biomass systems. Economical adaptations for the marine environment are still being developed. Few on-site structures will be used in the first generation harvesting. Processing likely will take place onshore.

Planners feel that at some point it will be feasible to have large areas of the ocean layered with underwater mesh 40-100 feet below the surface. The mesh will be used as the substrate to grow the kelp. Other technological components of the cultivation system will include intake pipes of wind or wave powered pumps placed 300 to 1000 feet below the surface to create an artificial upwelling of nutrient rich bottom water. Harvesting will be accomplished using adaptations of the mechanical reaper barges presently in use for the commercial seaweed industry. A processing and accommodation platform with transshipment facilities will complete the "farm" layout.

In theory, a kelp/biomass farm also could include animal husbandry capability, and thus become the offshore equivalent of an onshore farm.

Much the same layout-technological system is envisioned for the cultivation of more traditional land plants in the marine environment. The most important technical barrier to that application is not related to the marine application at all; rather, it is the time it will take to breed salt-resistant plants.

Current projections are that each square mile of marine farm could yield enough food to feed 3000 to 5000 persons and still produce enough energy to support 300 individuals at today's per capita consumption. If worldwide ocean farming systems were developed in the 1990-1995 period at a baseline of 100,000 acres of cultivated ocean, and grew at a rate of 12% a year, by the end of the forecast period more than 90 million square miles could be under cultivation.

6. Current and Forecasted Geographical Locations

Given the geophysical requirements for kelp cultivation:

1. calm, warm water
2. depth of 1000 feet to supply nutrients and upwelling pipe
3. little use conflict

Lower California waters are ideally suited. It is assumed that commercial development therefore will begin at that location.

7. Onshore Impacts

- o Employment
- o Improved food supply
- o Use conflicts

8. Primary Motivation Factors/Barriers/Obviating Factors

Motivating Factors	Barriers	Obviating Factors
Depletion of Nonrenewable Resources for Energy	Highly Capitalized	Substitute Protein and Food Sources Developed
Byproducts of Fermentation include fertilizers, other needed products	High Economic Risk. Far from Economic Feasibility	Substitute Energy Resources Developed
Demand for Food	Regulatory Structure Uncertain	Alternative Energy Consuming System Adopted
Land Farming Involved in High Competition for Arable Land	Use Conflicts	
	Geophysical Limitations	
Technical Barriers Seem of Applied Nature Rather than Demanding New Breakthrough	Alternative Sources of Energy and Food May be Less Expensive to Develop	
Opportunity to Increase Overall Productivity of a U.S. Industry While Creating Energy		

9. Development Process

Inadequate Data for Evaluation

10.

Forecasts	1990-1995	1995-2000	2000-0005
At sea agricultural production of kelp and other seaweeds increases because U.S. consumers demonstrate willingness to substitute them for traditional plants	L	L	L
Consumer interest in traditional onshore plants remains strong	H	H	H
Establishment of small number of kelp farms, with onshore fermentation into energy, food	L	M	H
Establishment of small number of kelp farms with on-site structures for processing	L	L	M
Traditional onshore food plants adopted and cultivated offshore	L	L	L
Major developmental push, priority given for development of marine agriculture with on-site experimental processing in selected locations	L	M	H
Zoned areas created for marine agriculture	L	M	H
True offshore "farms" combining plant and animal culture, harvesting, and processing developed	L	L	L

APPENDIX TO CHAPTER 5 OF VOLUME II -- MINERALS

OFFSHORE MISSION CATEGORY: MINERALS

1. Mission of operating system: extraction of non-energy minerals from the coastal margins or the deepsea.

2. General description of mission: Find extract minerals in commercial quantaties. Marine mineral deposits can be classified on the basis of their origin and the methods used to recover them.

- o Unconsolidated deposits
  - Non-metallics

    Sand and gravel
    Silica sand
    Industrial sand
    Sillimanite
    Staurolite
    Garnet
    Refractory muds
    Calcium carbonate

  - Heavy metals

    Heavy mineral sands
    Magnetite
    Ilmenite
    Rutile
    Monazite
    Chromite
    Zircon
    Cassiterite
    Xenotime
    Beryl
    Columbite
    Cinnabar

  - "Native" metals

    Gold
    Platinum
    Copper
    Gemstones
    Diamond
    Precious corals
    Pearls

- Surficial/Substracial

  Phosphorite
  Barium
  Sulfate
  Concretions
  Glaugonite
  Silicate
  Nodules
  Dolomite
  Hemipelagics
  Blue mud
  Volcanic mud
  Red and yellow mud
  Gravel
  Sediments
  Organic muds

o Consolidate Deposits

- Surficial

  Coral
  Barite
  Bauxite
  Phosphorite
  Manganese Nodules
  Argonite

- Underground "hard rock"

  Coal
  Iron ore
  Limestone
  Lode and vein deposits of all elements
  Sulfer
  Metalliferous muds

- Fuel

  Coal
  Shale oil
  Fluid hydrocarbon
  Helium
  Sulfer
  Sulfides
  Chlorides
  Nitrates
  Carbonates
  Iodates
  Borates
  Hydrothemal fluids

3. <u>Historical Development</u>:

The world's continental shelves comprise an area larger than North

America and only slightly smaller than Africa. The U.S. OCS (to a depth of 200 meters) include about 930,000 square miles. For the most part, data indicate that the mineral content of those areas is very similar to the well explored onland mineral content. Accordingly, there is strong geological reasons to expect that substantial mineral resources exist in the OCS. When the potential minerals of the deepsea are factored in, it is clear that the globe's OCS and deepsea beds represent a tremedous potential source of minerals. While many of these coastal mineral resources, for instance sand and gravel or shell, have been exploited for as long as man has dwelt near the sea, others--and all deepsea mining operations--have until fairly recently been conceived only in the most visionary minds.

When deepsea mining of marine mineral resources is discussed, the term usually refers to extraction of manganese nodules, although the same technology and techniques are applicable to a number of other unconsoladated or consolidated minerals resting on the seabed or a few feet beneath it. In 1876 the famous English research voyage of the Challenger discovered the existence of aggregated mineral lumps on the ocean floor in the Pacific. Subsequent exploration confirmed their presence over much of the total seabed.

It was not until the mid 1960's, however, that recovery and processing of these nodules was contemplated on a commercial scale. The deepsea nodules are composed chiefly of manganese and iron oxides. In some locations, however, they are relatively rich in nickel, copper, cobalt, molybdenum and vanadium. Nodules are abundant over large areas of the deep ocean floor. Current commercial interest is centered on nodules with a combined nickel/copper content of 1.8% or more.

There has been a dramatic increase in interest in the minerals that can be extracted from manganese nodules because of a wide spread predictions that onland U.S. reserves of a number of those minerals will soon be exhausted, and because of a growing dependence on imports for others. For example, over the

last decade the U.S. has imported about 20% of its copper, 78% of its nickel, 95% of its manganese, and 98% of its cobalt. Furthermore, there are estimates that the land based supply of copper, nickel and cobalt will be exhausted in a mere 40 years. It is the continued, and unlikely to fall, demand for these minerals, combined with rapid technological advances, which have made commercial deepsea mining potentially economic.

In contrast, certain near shore coastal resources like shell, limestone, sand and gravel have been mined, in one form or another, since at least the neolithic period. Coastal mining, accomplished by conventional dragging methods, presently has an economic depth of between 600-1000 feet. Of the minerals that are found near shore, only a few have been mined. The near shore marine minerals which are of historical economic interest include, in addition to these already mentioned, tin, sulfer, coal, barite, platinum, iron sands, chromite and gold.

4. Level of Activity/Current Usage:

On a commercial scale, the largest coastal mining systems currently in operation are in the United Kingdom, Denmark, Holland, Sweden and the U.S.. Both historically and in terms of current quantity and value, sand and gravel are by far the most important coastal mining operations.

Within the U.S. there are at least small sand and gravel operations on virtually all of the coastal areas, although the biggest have been in New England. Such operations are coming increasingly under scrutiny because sand and gravel dredging can cause severe environmental problems if not carefully conducted.

Shells are presently being mined in U.S. waters in all of the state estuaries leading to the Gulf of Mexico. That material is used for road fill and as a source for calcium carbonate which is then used to manufacture cement. Extensive prospecting is under way in Alaskan waters for gold, and in waters off California for phosphate. There is an active sulfur mine offshore Lousiana utilizing a combination of onland sulfur mining techniques and offshore oil technology.

At present there are no deepsea mineral commercial operations anywhere in the world. There are, however, a number of experimental pilot programs designed to test and establish the economic feasibility of such deep water operations. If legal and environmental matters are cleared-up industry spokesman feel that the the early 1980's will be the "take-off" period for commercial application of deep-sea mining and processing of ocean minerals.

Four North American organizations are now developing deep ocean mining systems. All four have formed consortia made up of both domestic and foreign firms. Additionally, one other group, Ocean Resources, INC. is a syndicate of more than 20 mineral and energy companies. They are developing deepwater mining technology and plan to disband following the licensing of any perfected technology.

The four U.S. consortiums are made up of the following companies:

- Deepsea Venture Group: U.S. Steel, Union Miniewre, and Sun Ocean Ventures. This group has filed a mine claim and has announced evaluation of a processing system.

- Kennecott Cooper Group: Kennecott Cooper, Rio Tinto Zinc, Consolidated Goldfields, Noranda Mines, Mitsubishi and BP Minerals. This group is still in the experimental stage.

- International Nickel Group: INCO, Arbetisgemeinschaft Meere-stechnisch-Gwinnbare Rohstoffe, Sedco, Inc., Deep Ocean Mining Company and Ocean Management Inc. This group is conducting at-sea testing.

- The Ocean Minerals Company: Lockheed Ocean Systems, Amoco Minerals Company, billiton International Metals, B.V.(a Royal Dutch Sheel subsidiary) and Bos Kalis Westminster Ocean Minerals. This group conducting onland testing and evaluation of mining system components and lab testing of processing techniques.

5. <u>Projected Use, Trends, and Technological Forecasts</u>:

In the 1970's spokesmen for the major international consortium cited 1980 as the year by which commercial deepsea mining of at least manganese nodules would be underway. While technical and legal questions delayed that date, and both are still unresolved, those same spokesman still feel that there will be some deep water mining in place in the early 80's. At present, industry feeling is that we are at a point of technological and financial preparedness. The major

remaining obstacles to commencement of full-scale operations are unknown questions of environmental impact and clarification of a number of legal technicalities; although, as pointed out in Chapter 5, those legal ambiguities may be about to be settled by the Law of the Sea Conference.

Demand pressures for the minerals found in nodules will probably determine the speed of actually putting deep sea mining systems in place. Mining of nodules is already well within the state-of-the-art. Tests of current technology have recovered nodules at a depth of 18,000 feet. After years of experimentation variations of three methods are the techniques being considered for commercial application:

- o Dragline bucket
- o Hydraulic Suction Dredging Methods--self-propelled dredges feeding into a mining ship
- o Continuous line-bucket methods
- o Future Developmental concepts (operational feasibility envisioned beyond study period)
  - semi-buoyant crawlers with a number of vacuum dredge heads
  - bottom crawler with large wheels with gathering devices
  - on site processing of deepsea mineral resources

Projected technological improvements for the near shore mineral mining systems involve, for the most part, improvement and modification to current systems to allow for more efficient operations or to reach greater depths. Envisioned improvements of concepts include:

- o Bucket ladder dredge
- o Hydraulic suction dredge
- o Semisubmersible dredges

Future technology includes:

- o Walking self-elevating platforms--similar to fixed oil and gas exploration plagrorms but with capability to "walk" to the mine

- o Remote controlled semisubmersible suction dredge
- o Air lift dredges

It is not anticipated that a large scale ocean mining industry will be in place before 2000, but thereafter a larger percentage of basic minerals, especially copper, nickel and manganese, will be produced from deepsea mines. Most experts argue that in this sense the move offshore will be a natural expansion of the history of on land mining. The on land industry is now in a situation where there are very high costs to exploit fairly low grades of minerals. In the infancy of the mining industry just the opposite was the case: only the very richest grades were mined. While the cost of ocean mining will be very high the grades of minerals initially exploited will also be high.

Even though ocean minerals are, like on land minerals, finite, it is assumed that technological improvements in the "second generation" of deepsea and offshore mining equipment, including on-site processing, will allow areas mined out by the first generation mining systems to be economically re-worked. Therefore, many experts feel that by the mid-21st. century ocean resources may be the prime source of many minerals.

6. Current and Forecast Geographical Locations:

Current locations are given in Section 3. U.S. Potential locations are:

1. Gulf of Maine: shallow water load[illegible] chiefly sulfides, sand, and [illegible] heavy metals
2. Massachusetts Coast: Cape Cod Bay and Buzzards Bay have some potential sand, rare earth heavy minerals and coal
3. New Jersey/New York Bight: sand
4. Southeast Atlantic Coast: Beach resource of heavy minerals sand, possibility of OCS heavy mineral sand
5. Gulf of Mexico: Oyster shell, titanium bearing sand, metal sulfides

6. Southwest Pacific Coast: Sand and gravel, phosphorite

7. Northwest Pacific Coast: OCS palcer deposits of gold and heavy metals

8. Great Lakes: Manganese and copper ore

9. Bering Sea: Placer deposits of gold, platinum, tin, tungsten rare earths, Lode deposits include: barite, copper, lead, zinc, chemical precipitates of uranium bearing minerals

10. Arctic Shelf: potential unknown

11. Insular States and Territories: volcanic and basalt minerals, manganese crusts

The most promising deepsea area for nodule mining is in the northeastern Pacific between the Clarion and Clipperton fracture zones. Few other areas will be considered until advances in nodule mining and processing technology are coupled with the depletion of higher grade sources, bringing within the economic range other lower grade global deposits. Since ocean nodules differ widely in composition depending upon their location, it is difficult to predict with any confidence the "second" generation areas because that will partially be determined by onshore supply or depletion of specific minerals and which world location contain nodules with a high concentration of that mineral.

7. Onshore Impacts:

Nodule mining in particular may have significant social, economic and environmental impacts, although for the most part these potentialities are but incompletely understood.

Potential pollution of the marine or onshore environment will depend, of course, upon the specific mining methods and environmental conditions of each operation, as well as whether or not the operation takes place on the OCS, near shore or deepsea. Most researchers have identified three classifications of possible environmental impacts from mining systems:

1. Alteration of the shape of the sea bed

2. Interference with other uses of the area

3. Disturbance of marine or estuarian ecosystems

Since the first generation of mining will largely take place well away from land, there will be little possibility of damage to beaches or other recreational facilities. Similarly, the sites listed as having the most potential for the first generation exploitation are well away from major shipping lanes and are at present well off areas of interest to commercial fisherman.

Questions of use conflicts are and will be far more pressing for shallow water OCS near shore mining operations. Already, there are significant conflicts between such operations and U.S. commercial fishing. The experience of Europe also indicates that a large increase in mining operations near shore will result in a large increase in marine accidents, especially ship collisions as marinars attempt to navigate around mining installations.

In addition to the rather obvious impacts which mining share with other offshore installations on local employment and infrastructures, and the very real security and "quality" of life impacts of an assured domestic supply of certain minerals, another range of economic impacts will deal with the industrial structure of the U.S. mining industry. These issues will deal with traditional antitrust policy. The resolution of the questions will have important implications for how quickly and efficiently the offshore mining industry developments, and whether or not that developments is left in private hands or placed into some sort of quasi-public corporation similar to Comsat.

There is some concern that the Justice Department or the Federal Trade Commission may not be satisfied with the structure of the industry as it appears to be developing today. For example, there is some question that with the present structure of four consortia controlling virtually all American investment committed to deep ocean mining, entry into the industry will be easy, and that consequently competition will be fostered. It is clear that whether it is intended or not current federal policy is encouraging an oligopolistic

structure in ocean mining. A peripheral issue is whether it is necessary to have a fully integrated structure for mining operations. At present, the consortia participating in the industry have a fully integrated structure enabling them to be involved at all steps in the process from actual extraction of the minerals (and all infrastructural support) to the final processing and marketing stages. Current precedent in the offshore oil industry appears to dictate that such full integration will, at some point, be broken up by U.S. anti-trust theory. Since integration may, because of the very high capital and time requirements of offshore mining be necessary to attract investment capital, the actual form of development may take a shape dictated by adjustments to anti-trust law.

Under certain conditions nodule mining may have other important economic impacts on the structure and economics of on land mining or on local regions, depending on a number of variables:

- When production starts
- What the rates are in early stages
- How the industry develops
- The demand for different minerals in respective years

8. Primary motivating Factors/Barriers/Obviating Factors

Motivating Factors	Barriers	Obviating Factors
EXPECTATION that ocean mining will provide opportunity for high growth industry	Competitive economic costs	Decline in industrial society
Demand for minerals greater than land based supply	Environmental risks	Substitute technological developments to fill present mineral demand
Need for greater national supply independence	Conflicting uses	Overriding loss of socio-political stability
Advancing technologies to find and develop techno-logical feasibility	Geophysical requirements	
Recognition that present corporate capabilities and skills will be transferable	Uncertainty of legal jurisdiction	
	Uncertainty of techno-logical capabilities	
	Capital costs	
	Regulatory uncertainty	

9. Development Process:

This process is described in detail in Chapter 11 of Volume II.

10. Forecasts	1990-1995	1995-2000	2000-2005
High industral economic growth is preferred choice of society	H	H	H
Mining of ocean mineral resources becomes element in national policy	G	H	H
Cost disadvantage of offshore mining lessened by:			
improved technology	H	H	H
supply depletion	G	H	H
supply cartels	H	H	H
high cost for lower grade land based supply	G	H	H
Substitute consuming systems will be developed to lessen demand for minerals	L	L	L
Environmental issues will grow in importance	H	H	H
Environmental issues will stop or reverse development of offshore mineral reserves	L	L	L
Environmental issues will slow development of offshore mineral reserves	G	H	H
Market conditions determine minerals extracted	L	G	H
Hard rock mining for coal spreads to ocean	L	L	G
Protection of living reefs and surrounding ecosystems, achieved by dredging heads which operate in specific areas and do not redeposit impurities on ocean bottom	G	G	H
Increased utilization of submersible dredges for immediate offshore extraction of sand, gravel, limestone, and shell; satisfies regulatory and environmental concern over disruptions of underwater environment and becomes economically advantageous over surface dredges	G	H	H
Placer extraction adopts technologies utilized for offshore extraction of sand and gravel and becomes actively pursued	L	G	G

10. Forecasts	1990-1995	1995-2000	2000-2005
Nodule extraction develops rapidly fostered by international competition and high value of minerals	L	G	H
Technologies utilized extraction include:			
o Bucket line systems	G	H	H
o Hydraulic suction systems	G	H	H
Mining nodules become important, though only a partial source of national and international mineral supply	M	L	G
Extraction of red clay/ooze experimentally developed	L	G	G
Ocean extraction significantly supplements land-based supplies of phosphorites	L	L	L
Inherent high value of mineral deposits found within metaliferous muds activates pursuit of this resource, utilizing technologies applied in oil and natural gas production and deep sea mining	L	G	G
Chemical extraction of minerals such as salt, bromine, and manganese will continue in land-based facilities adjacent to the ocean	H	H	H
Salination projects expand in areas of extremely arid climates	H	H	H
U.S. develops economic feasibility studies for demonstration desalination projects within this country	L	G	G
Actual development of salination as major supplier of water in areas such as southern California	L	L	G
Iceberg towing actively pursued by nations with year-round arid climates	G	G	G

APPENDIX TO CHAPTER 6 OF VOLUME II -- SEAWARD EXPANSION OF INDUSTRY

OFFSHORE MISSION CATEGORY: SEAWARD EXPANSION OF URBAN SYSTEMS/INDUSTRIAL DEVELOPMENT

1. Mission of Operating System: Expansion of traditional onshore industrial functions into marine environment.

2. General Description of Mission: Manufacture industrial products in the marine environment and provide living and recreational facilities onsite for workers and their families on permanent artificial islands, or fixed platforms, or floating platforms.

3. Historical Development: In the early seventies it became evident to many observers that continued economic growth on the East coast would be difficult and would lead to increasingly adverse effects on the environment. This is seen as particularly so because the U.S. is in a position where its major industrial centers, dependent on water transportation, are located on bays, rivers and estuaries that are generally too shallow to take modern ships and too small to assimilate more wastes as well as being incredibly valuable and fragile as biological and recreational resources. The interest in solving these and the consequent social problems in metropolitan areas has resulted in discussion of the possibility of locating various industries and transportation systems on offshore islands or platforms complexes.

Further, America is now confronted with a complex situation affecting its ability to maintain both a vigorous economy and an adequate defense posture. Because of a broad range of economic, social and environmental constraints, it has become virtually impossible to find appropriate sites for deep water ports close to areas that can accommodate, or that want, the heavy industrial plants for refining bulk petroleum into oil products, or manufacturing of other industrial products. Many, if not most, of those products are very heavy consumers

of energy. Therefore, they can best be sited close to generating plants. But, it is also becoming more difficult to find sites for electric generating plants to service the coastal metropolitan areas.

The underlying justification behind the concept of marine sited industrial islands or platforms suggests that in traditional on land siting, even if development is feasible, there are some industries that are necessary but noxious. It argues that based on both environmental concerns and the geography of demand the development of offshore industrial complexes may be the best long-range solution to the complex socio-economic problems now facing ports of the east coast and with time the entire nation.

4. Level of Activity/Current Usage:

None. Although, all of the missions discussed in this report could be described as experimental applications of designs and concepts necessary for this mission to become operational.

5. Projected Use, Trends and Technological Forecasts:

This general category is very amorphous since, in terms of technology and actual missions, it derives from and contains elements of all other categories. For that reason, it actually deals with the effects of economic, social and cultural change after a long term (far beyond the scope of the present work) slow but steady creep seaward of all missions with their associated infrastructures. That is, if this mission category is fully implimented, it will be the sum total of all of the other categories and missions: the result of an unplanned, evolutionary process.

(1) Increase in oil and gas rigs → more offshore support facilities,

(2) Offshore power plants (of any type) → industrial port islands and floating industrial platforms

(3) Creation of more offshore support facilities, including temporary housing for crews and workers---------- temporary housing for families to ease strain of long work shifts and cut travel expenses

(4) Full scale permanent residential-commercial, industrial communities

The main criteria used to determine the best industrial users of an offshore platforms or island have been such questions as the importance of the industry to the economy and National defense, the degree of difficulty in plant site acquisition, the source, volume and form of raw material used, how noxious, nuisance of hazardous the industry may be, and whether the industry is labor or capital intensive. Based on such criteria concerns list of industrial candidates can be developed. The list includes:

- Petroleum refining
- Petrochemicals manufacturing
- Nuclear and fossil fueled electric power generation
- Deep water materials
- INC regasification
- Urban solid waste processing and disposal
- Fertilizer manufacturing
- Paper manufacturing

- o Electrometals processing
- o Iron reduction and steelmaking
- o Nuclear fuel reprocessing

Such island industries could be organized in any number of combinations. In most models, for example, the core industry could be fossil (or nuclear) fueled electric production for the mainland. Satellite industries could be sited around the availability of "excess" power. Another possibility could be a petrochemicals factory or a refinery acting as the core around which an industrial complex is built. The type of core industry selected would depend upon environmental factors and the most pressing industrial/development needs of the island's hinderland. For the reason, a discussion of the various hinderlands needs of American urban areas is necessary as a part of any analysis of the present of future feasibility or desirability for the construction of an offshore industrial/port island in any single location. The region selected most often for case study because its problems are more advanced is the New York-Notheastern New Jersey Metropolitan area.

There are several techniques currently available for constructing an industrial/port sea islands. The Netherlands, in particular, has been very successful in such open-sea construction. There are five different construction techniques: 1) unprotected beach; 2) polder; 3) dike and fill; 4) sheet pile cell; 5) caisson. It should also be pointed out that combinations of fixed or floating structures sited around deep water port terminals could also be adopted to offshore industry.

Most studies have concluded that unprotected beach and polder type construction are not well suited to open water conditions. The unprotected beach requires huge amounts of fill and vigilant, constant maintenance is necessary to

replace fill material lost to wave action. Polder type construction has the strong possibility of catastrophic failure in adverse storm or seismic conditions, with a total loss of life and concomitant pollution.

A number of engineering factors must be evaluated to select the specific location of an industrial port island: seismic events, existance of coarse sands or gravels for foundation material, proximity to transportation, oceanic variables such as waves, tides, strong surges, dominant winds and currents, frequency of hurricanes or tornadoes, or the amount of fog or ice. The best shape for a sea island is a circle because it maximizes area and minimizes the perimeter to protect with armor.

In the advanced planning and design stage, with a committed capital investment, are floating nuclear power plants and liquified natural gas facilities. In advanced concept design are floating airports and fossil-fueled power plants as well as many other offshore industrial facilities. In fact, there are very few, if any, urban or industrial activities which could not be carried out on an artificial, floating or quasi-floating platform, given current technology. A number of factors combine to make the use of such facilities attractive: stability, economics and environment.

- o Platform stability--a technological necessity for sophisticated activities at sea has been achieved by using platforms with very large displacements or semisubmerged platforms.
    - Stability has been achieved to the point that it is possible to design platforms that will never exceed acceleration of .02g.
- o Stability has resulted in platforms being cost competitive with a land-based counterpart if:
    1. Multiple production in a single facility (economies of integration)
    2. Economies of scale
    3. Use of prestressed concrete

4. Elimination of site-specific design

5. Cheaper logistic connections

- The emerging conclusion is that platforms are economically equal to or superior to land-based counterparts when the function to to be performed requires high volume to area ratios, when the absolute size of the structure is over 15,000 tons, and where competing land costs are high

  - Therefore, office buildings, bulk storage facilities, manufacturing plants and power facilities are good choices for floating facilities, but concepts like airports, requiring large amounts of surface areas, are not, and may never be cost competitive

- Environmental and social issues are covered under onshore impacts, but in general, urban clusters of platforms are so expensive that they will not be planned, but will evolve. Three things would be needed to establish floating residential/commercial communities:

  1. Very stable, large platforms (already technologically feasible)

  2. Community acceptance to the concept (strong in Europe and Japan, only slowly emerging in the U.S.)

  3. Evolution of rapid, cheap, low-motion mass marine transportation

- All three evolutionary trends already are well established.

6. Current and Forecast Geographical Locations

The U.S. region considered the most likely candidate for the first application of full-scale offshore industrial development is the Northeast. That is so because the region has a number of advanced economic, social, and land-use difficulties which perhaps can be best solved by seaward expansion of industry.

Perhaps the most serious and persistent problem in this region is a steady economic decline which began in 1969. Total employment in the metropolitan area has fallen by at least 600,000 persons, mostly in manufacturing. Many companies have closed, and investment in the region's infrastructure has shown the same steady delination. This disappearance of heavy industry from the area has had

a high multiplier effect so there has been a consequent population loss.

A second, equally severe problem has been both high energy costs and periodic shortages in the supplies of the fuels required for energy production. The New York portions of the metropolitan area have the nation's highest electric rates and the entire area suffers periodic brown-outs or other power shortages. The New York metro area is relying more and more on oil. 78% of its energy is oil fueled compared to a national total of 48%. Most of this oil is imported. Because of air quality standards the region's utilities may not use coal or high sulfur oil. Therefore they are totally dependent upon oil produced outside of the region.

Thirdly, as a "mature" urban area most of the infrastructure such as sewage systems, water systems, highways and the other transportation systems are very old and in desperate need of replacement or expensive maintenance. This is generally true of the area's factories and other industrial facilities as well. Consquently, decisions must be made whether to upgrade existing systems by costly repair or to replace them with at least equally as costly new systems.

All of this has lead to serious consideration of the construction of an offshore industrial island or series of floating installations as a partial solution to some of these difficulties. The region is very densely populated so it is presently nearly impossible to locate new sites for new major industries. Even if the sites can be found it has proved equally as difficult to find local agreement about what industries are acceptable. As a consquence, the region's utilities have been unable to find locations for new or replacement power plants, the chemical industry cannot expand, and the petrochemical industry can not find room to build or expand. Also, because of its high population concentration the region is seen as completely unsuitable for the siting of "dangerous" facilities such as LNG and nuclear plants. It is therefore unable

to increase the supply of natural gas or electric power which could lower the area's dependence on imported oil somewhat.

Another problem, which will probably become increasingly apparent in the future, is the feeling around the country against putting up with more pollution in order to produce the fuels or energy necessary to the entire Northeastern part of the U.S. Thus, in the Northeast there is extreme pressure to find or develop a reasonably convenient location which would eliminate or alleviate the environmental, social and economic restrictions combining to virtually prohibit the location of badly needed facilities on-land.

Given that the Northeast Atlantic coast lacks suitable onshore industrial cities, that refinery siting appears to have been a particular problem, and that there is no deep water port capability, many researchers conclude that an offshore oil refinery or an electric power generation plant would be the most suitable core industry around which to construct a complex.

As we discuss in Appendix 2, another probable area to evidence evolutionary trends of industrial development seaward is the Gulf of Mexico. The first generation American manufacturing sited in the marine environment is likely to be the production of energy intensive products on platforms sited near and serviced by OTC power plants.

7. Onshore Impacts:

The underlying premise uniting many proposals for offshore industrial development is that while the general public has been taught that the open ocean is the most fragile and easily polluted of man's environments, in fact it is the easiest and safest environment for the industrial processes vital to our society. A major and very important caveat is that such an assumption does not apply to estuaries, small bays and other bodies of water which have limited circulation. For that very reason, since such coastal areas are precisely where

most industrialization is placed today, many environmentalists argue in favor of siting polluting or dangerous industries and activities, on the OCS. As long as due care is taken to protect the food chain and the facility is sited at least three miles from shore, the ocean is environmentally superior to other locations.

Regardless, offshore siting will not become a cure of all our problems. Very careful planning for the environment is still required. Particulate emission control, liquid waste treatment and disposal, spill safeguards and control of dangerous elements are just as important offshore as on-land. Some of the most important island or platform environmental advantage include: use of the ocean as a heat sink: noise abatement; solid waste treatment. In addition, and probably more important for the long term, it may be far more desirable from an environmental standpoint to present or rehabilitate estuarine area at the cost of potentially less productive shelf locations.

Impact studies, for example, on existing artificial islands are rather optimistic. While turbidity, bottom habitat destruction and other construction impacts had a short term negative effect at a artificial island (Rincon Island) built at Punta Gorda California, the major ecological finding were positive. They indicated the development of a mature, balanced and diverse fish population from a previously depauperate condition. No catastrophic effects were found in spite of the fact that the island was constructed to act as a permanent platform for oil and gas production. It is clear that there is a risk of catastrophic spills of toxic chemicals, industrial accidents like LNG explosions, or other events which would result in situations which can be classified as ecological catastrophes, but those would be the result of an extraordinary event and not a logical or necessary outgrowth of siting the facility. One problem is that as yet no artificial facility has been constructed on the magnitude of the envisioned offshore industrial port island. Considering the volume of fill

necessary dredging could take 10-15 years. That would increase turbidity and bottom habitat destruction considerably. It is not really known whether the island habitat would be enough to offset such massive disruption.

The estimated cost to construct an industrial platform or port island complex are very high, at least $550 million for a small island facility. These costs consider such operations as mobilization, dredging and sub-base preparation, rock protection, sand fill, deepwater channel, emissions, breakwater, and berthing facilities. When these costs are added to the five billion investment in processing equipment, it is clear that even in an offshore economic system where high costs are routine, the start up expenses of an offshore industrial complex are astronomical. Proponents of such construction argue that the true cost of the facility can be judged only when activity and real estate value have been integrated for maximum effectiveness while recognizing relative cost differences between natural and created land, the potential cost difference in pollution management, as well as the potential environmental improvement and a high social dividend. An example of a facility and its inputs/outputs follows.

The key input to an island with a refinery core (this example assumes 500,000 bbl/day) is imported crude oil or oil produced in near-by offshore fields. The key outputs are refined petroleum products and petrochemicals. All of other tenants are extension of the key facilities, being secondary processing, maintenance and operating support. The industries in this example are: refinery, petrochemical, fertilizer, paper, seafood, power generation, desalination and a waste treatment facility common to all facilities as well as a separate municipal waste treatment plant.

The crude refinery and petrochemicals plant produces high value clean fuels, industrial chemical feedstocks and polymers for export. Gas not used by the refinery would be used as fuel and feedstock by an ammonia fertilizer plant. Re-

finery wastes having fuel value power the island's steam electric power plant, waste heat from the refinery and power plant is used by the food processing and paper plants. Chemical effluents are processed in the island's own waste treatment plant achieving chemical recovery as well as maximum water reuse. Steam and electricty are supplied by the power plant, which could also send power to the mainland. Fresh water is produced from sea water. Brine from the desalination plant is evaporated and further processed into commercially usable salt. The acid requirements are supplied by an acid plant using water materials from the other processes. Thus, the island's liquid wastes approach zero.

The size of such facility based on the current state of the art, would need to be 1800 acre. It would employ 1600 people per hour shift. The investment in processing unit would approach 5 billion dollars. Assuming 2 eight hour shifts, total direct employment on such an island would run about 3200. If a third shift was used employment would, of course be 4800. Indirect employment (defined as necessary support services which are not direct hire jobs but which depend on the facility; e.g., onshore supports supply vessels, etc.) could run at least another 950 jobs. Induced employment (defined as that employment generated by island related spending or wages spent within the regional economy of the island's hinterland) could increase employment by a further 4608 jobs. Thus, one rather modest sized offshore port/industrial island could generate 10368 new jobs during its operation. Even more jobs would be needed for the construction period of such an Island, which could take ten to fifteen years.

When the value and need of the facility's outputs are added to onshore benefits and environmental improvement, it is clear that the potential social dividend from offshore siting of industrial facilities is high indeed.

8. Primary Motivation Factors/Barriers/Obviating Factors:

Motivating Factors	Barriers	Obviating Factors
Decay of urban infrastructure and cost of replacement	Large capital investment required	Technological breakthrough in hazardous, noxious of unpopular facility siting
Public opposition to siting industries near residential areas	Largely untested technology	Safety land use environmental impact transportation
State, local, federal environmental standards	Conservative natural reluctance to invest in completely "new" concept	Dramatic population decline
Social-economic cost-benefit of onshore land preemption	Need for cheaper personnel, material transportation from shore	"Limits-to-growth acceptance of lower standard of living
Cost of onshore construction	Social/psychological factors	Abandonment of "mature" urban areas
Technological improve-giving platforms more stability	Uncertainty of governance	Breakthrough in need for traditional energy resources
Easier to enhance economics of scale	No regulatory/police framework inplace	
Easier to enhance economies of integration	Need for support services like medical care	
	Anti-trust law	
Lower raw material transportation costs	Environmental concerns	
Platforms cost competitive to land for high volume to area ratios		
More environmental suitability, in most cases, than the same industry sited onshore or near shore		

9. Development Process:

This is unclear, but will follow the general stages given in the Growth Model.

10. Forecasts:

Forecasts	1990-1995	1995-2000	2000-2005
Full scale floating cities	L	L	L
Temporary accommodations for workers siting small number production facilities (energy intensive) offshore near OTEC power stations	L	M	H
Siting dangerous, noxious or unpopular industrial developments offshore	L	L	M
Deepwater ports off major U.S. Urban areas	L	L	L
Floating airport offshore U.S. city	L	L	L
Artificial industrial port islands built on U.S. OCS	L	L	L

- o Electrometals processing
- o Iron reduction and steelmaking
- o Nuclear fuel reprocessing

Such island industries could be organized in any number of combinations. In most models, for example, the core industry could be fossil (or nuclear) fueled electric production for the mainland. Satellite industries could be sited around the availability of "excess" power. Another possibility could be a petrochemicals factory or a refinery acting as the core around which an industrial complex is built. The type of core industry selected would depend upon environmental factors and the most pressing industrial/development needs of the island's hinterland. For the reason, a discussion of the various hinterlands needs of American urban areas is necessary as a part of any analysis of the present of future feasibility or desirability for the construction of an

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offshore industrial/port island in any single location. The region selected most often for case study because its problems are more advanced is the New York-Notheastern New Jersey Metropolitan area.

There are several techniques currently available for constructing an industrial/port sea islands. The Netherlands, in particular, has been very successful in such open-sea construction. There are five different construction techniques: 1) unprotected beach; 2) polder; 3) dike and fill; 4) sheet pile cell; 5) caisson. It should also be pointed out that combinations of fixed or floating structures sited around deep water port terminals could also be adapted to offshore industry.

Most studies have concluded that unprotected beach and polder type construction are not well suited to open water conditions. The unprotected beach requires huge amounts of fill and vigilant, constant maintenance is necessary to replace fill material lost to wave action. Polder type construction has the strong possibility of catastrophic failure in adverse storm or seismic conditions, with a total loss of life and concomitant pollution.

A number of engineering factors must be evaluated to select the specific location of an industrial port island: seismic events, existence of coarse sands or gravels for foundation material, proximity to transportation, oceanic variables such as waves, tides, strong surges, dominant winds and currents, frequency of hurricanes or tornadoes, or the amount of fog or ice. The best shape for a sea island is a circle because it maximizes area and minimizes the perimeter to protect with armor.

APPENDIX TO CHAPTER 7 OF VOLUME II -- TRANSPORTATION

OFFSHORE STRUCTURE MISSION CATEGORY: Transportation

1. Operational System: Submarine power cables

   a) Designed to carry megawatts of electricity between distant areas of a grid system

   b) Cable carrying electricity from offshore energy promotion facilities, such as OTEC, offshore nuclear power plants, and wave power plants, to shore; includes bottom cable and a special fatigue resistant riser cable which spans the distance from a floating OTEC plant to fixed bottom cables at depths of 4,000 feet.

2. General Description of Mission

   - Subsea power cables are designed to carry megawatts of electricity between different areas of a large peak power loads to be shared over a wide range of power stations to even-out the load on each side of the water.

   - In order to exploit a variety of offshore energy alternatives, especially, OTEC, high voltage cables are required to carry the electrical power from the plant to the shore. The OTEC riser cable is a very critical element in the power transmission and to the overall success of OTEC.

   - Power cables play a role in offshore industrial development and have applications for oil platforms.

3. Historical Development

   - Underwater power cables have been installed and used since the early 1800s, soon after the first submarine telegraph cables.

   - However, their acceptance was slow initially, but their use has has acceleratd over the last half-century as the result of the replacement of natural rubber insulation.

   - In 1937 butyl rubber was introduced initiating the era of synthetic insulation which provided for much higher voltages.

   - Since the widespread use of butyl rubber, two trends have developed in insulation of submarine power cables

     - Pressurized variants of paper insulated lead, sheathed cables

     - Solid, synthetic dielectrics such as polyethylene followed by other plastics (thermoplastic and thermosetting)

4. Level of Activity/Current Wage

- Subsea power cables are less common than submarine communication cables

- Since 1953 at least 13 power cables of over 2 miles in length have been installed throughout the world. Pressure insulated cables, in some cases pressurized by oil and gas, have been used up to 138 kv a.c. and up to +266 kv d.c. Extruded dielectric submarine cables have been used up to 138 kv a.c. and up to +266 kv d.c. Extruded dielecric submarine cables have been used up to 138 kv a.c. but not for d.c. The majority of long submarine power cables have been the impregnated paper or the fluid pressurized paper type

- Currently the 3 basic insulating systems in use for power cables are oil-impregnated paper tapes, extruded synthetic and insulating gases

- One experimental OTEC plant has already been put in operation off Hawaii

- Most submarine power cable installations have been for short distances as compared to communication cables. They have been used for crossings of rivers, straits or open water to islands or offshore platforms.

5. Projected Use/Trends and Technological Forecasts

- Rock trenching machines will be developed to enable cables and pipelines to be laid in these areas

- Current submarine cable technology, must be further developed for OTEC in order to construct fatigue-resistant riser cables able to withstand constant motions arising from movement of the floating OTEC plant and from direct forces such as from waves and currents. Research has been underway to design and test fatigue-resistant riser cables.

- Problems faced in developing riser cables do not appear to be insurmountable. Viable riser cable system designs will be developed in the near future.

- Oil-filled self-contained cables, solid paper cables, and extruded-dielectric cables appear to offer the greatest potential for riser cables.

- To bring the transmission OTEC cable from the ocean floor several methods are possible: the direct riser,the mooring-supported riser, the riser tower, the subsurface buoy, and the coldwater pipe attachment. The direct riser and the subsurface buoy approaches seem to have the most favorable installa-

tion characteristics, with the buoy-supported system the most probable.

- The most suitable bottom OTEC cables are self-contained, oil-filled cables for short transmission links and paper-impregnated cables for long transmission links. No major technical problems exist for their application.

- In general significant progress is being made and the use of submarine power cables will expand.

  - Across lakes and rivers

  - Through the ocean because of OTEC

  - Between Hawaiian Islands

- The greatest technological developments and demands upon submarine power cables will probably result from OTEC over the forecast period.

- Offshore industrial development will cause increasing demand for power cables.

- Voltage and power levels for submarine power cables will probably increase DC power transmission, which is becoming increasingly in demand can be isolated from the AC portion, enabling much higher voltage levels to be reached. Development of higher voltage AC underwater cables is also being undertaken.

6. Current and Forecasted Geographical Locations

- Notable subsea power cables connect France and Britain and the north and south island of New Zealand.

- OTEC riser cables will be installed in 4,000-6,000 feet depths.

- Potential OTEC plant locations require a temperature difference of 20o c. between surface and bottom waters and are located from 20o North Latitude to 20o South Latitude.

- Suitable sites for OTEC are at least 150 to 200 miles from the U.S. mainland in the case of the West Coast of Florida and the Gulf Coast states (with cables connected to Louisiana and to Texas) but are within 5 miles off several U.S. islands including Hawaii, Guam, and Puerto Rico.

- Power cables may be laid between the Hawaiian Islands to connect them to carry electricity produced by geothermal energy and energy from biomass conversion.

7. On-shore Impacts

- o Employment and economic development from:
  - Cable production plant
  - Construction/deployment of submarine bottom and riser cables
  - Maintenance crews
- o Increased supply of domestic energy

8. Motivating Factors

- o Reduced dependence on imported oil
- o Employment and economic development
- o Local energy supply
- o Possible lower costs
- o Demands created by offshore industry expansion
- o Economics anb reliability of cables favor them over local generators for powering on offshore platform or island

Barriers

- o Technical deficiency for riser cables related to
  - Reliability
  - Mechanical loadings and motions imposed on OTEC riser cables: statics, current drag, strumming, and forcing by end motions
  - Mechanical fatigue from twisting, bending, and tension changes

- Other hazards and failures of riser cables—man caused activities, loss of plant station-keeping, abrasion, corrosion, cable fouling, chemical deterioration, excessive voltage, marine life effects, and unacceptable chafing of the cable

- Lack of data in long-term life evaluation of riser cables

- Proven designs of splices for riser cables do not exist and will be a major undertaking

- Hazards to the environment from the cables including: discharge of oil to the sea from a failed cable, electrical currents affect on marine life, and high voltage personnel safety conditions

- Investment costs

Obviating Factors

- Electrical energy from OTEC plants is brought to shore by making energy intensive products, such as aluminum, ammonia or hydrogen, which are shipped to shore for further processing

- Other forms of energy production found more feasible

9. Development Process

Administrative/Regulatory

- Cables in continental shelf depths must be accurately charted to caution ships not to anchor and to warn trawlers and dredgers against picking up or cutting the wire

- The Department of Energy is actively involved in the development of the riser cable system for OTEC. DOE will be seeking cost-sharing proposals from prospective owners for demonstration OTEC plants

OTEC Bottom and Riser Cable Construction/Design Requirements

- Power cables may need to be buried to 8 feet cover in water depths of less than 300 feet. Water jet pumps are used to bury cables.

- The basic electrical requirements for OTEC riser cables must account for the following: dielectric integrity, power transmission capability, compatibility with bottom cable, electrical loss considerations, production tests, over voltage protection, short circuit protection, grounding, maintenance, fault location and watertight integrity.

- Power conditioning space and weight requirements are necessary on the OTEC plant.

- Transmission distance will be important in determining the transmission voltage level and mode (a.c. or d.c.).

- Four cables would be a reasonable number required for an a.c. transmission operation and 3 cables for a d.c. operation. (This includes one spare cable).

- *Close coordination is imperative between design* of the OTEC station-keeping system and the riser cable system.

- A minimum of 10 feet for cable termination separation will be needed on board the OTEC plant to allow installation, repair, and recovery.

- The use of a non-conventional mooring system will have a substantial bearing on the design of the riser cable.

- Conventional cable ships, reel ships, or reel barges will be needed to lay riser cables.

- Planning for power cable installation must include: bottom surveying, route planning, equipment and vessel planning, ' cable handling, and crew training.

- Repair requirements: fault or damage location, mobilization, suitable weather. A permanent repair fleet at the OTEC site may be preferable to provide quick response to cable failure and routine maintenance. Annual cost of an on-station maintenance/repair vessel is $13 million (in 1976 dollars).

- The sea bottom connection between riser and bottom cables will probably be accomplished by a cable-to-cable splice rather than a back-to-back connecting device2

- Total installed riser system costs range from 8 to 39 million dollars2

- Reliability assessment-must prove to be high

- Facility for producing 500 miles of OTEC cable annually would cost $22 million

- Armored and armorless power cables each have their own advantages

- Extraordinary insulation required

- Appropriate riser cable terminal at the OTEC plant must be developed

Construction of power cables:

- Design considerations

  - Voltage and load

  - Line bosses of energy

  - Physical protection requirements

  - Manufacturing limitations

- Detailed planning and execution particularly for the installation stage

10. Logistical Support Systems

- Vessels: cable ships, reel ships, reel barges, tug, vessel for installing subsurface buoy

- On-station maintenance/repair vessel

- Subsurface buoys

- Crane

- Work boat crew
- OTEC transmission subsystems include: OTEC generators and power conditioning; shore-based electric substation and utility system
- Chains and anchors
- Cable production plant

OFFSHORE STRUCTURE MISSION CATEGORY

1. Operational System - Submarine communication cables and other

   a) Telegraph cables

   b) Telephone cables

      o Composed of complex bundle of conductors, insulating materials, strengthening sheathes of steel and plastic and waterproofing.

      o Today's modern coaxial submarine cables operate in the frequency-division-multiplex mode. The cables connect at their ends with electronic and power supply equipment. This equipment enables the generation of pilot and carrier frequencies and provides frequency translation. Cables also contain: directional and power separation filters, equalizers, transmit and receive amplifiers (repeaters) repeater monitoring apparatus, and constant-currnet power supplier for energizing the repeaters.

      o The repeaters are built into telephonic cables at intervals of 50 to 100 kilometers to improve the electrical signals that make up a voice message. Power for these small stations may be generated by heat from a radioactive isotope in each repeater.

      o Equalizers are typically inserted every 10 to 20 repeater sections.

   c) Other cable systems

2. General Description of Mission

      o To establish rapid communications between distant parts of the world for purposes of commerce, government relations, news, social needs, etc.

      o Cables also have a variety of other offshore applications including: hydrosphere research, offshore oil activities, mineral recovery, diving/submersible operations, televisions, and for mooring.

3. Historical Development

      o The technology of marine-cable laying was largely developed for telegraphic and telephonic communications as compared to power cables.

      o The first submarine telegraph cable was laid in the mid 1800's when Morse code was used. In 1866 a transatlantic link was successfully established from Newfoundland to Ireland.

- For the next 90 years after 1866 submarine telegraph cables were establish across every ocean. Major technical advances during this span included the development of duplex operation, inductive loading and signal regeneration.

- In the early 1900's submarine cable telegraphy was challenged by radio telegraphy, but both thrived together. Only recently was the last submarine telegraph cable discontinued whereas international radio telegraphy still has widespread use.

- For 30 years after 1927 overseas telephonic transmission was carried almost entirely by radio as a result of increased radio brand widths.

- Milestones in the development of submarine telephone cables:

  - Short cross-Channel telephone cable between France and Britain was operative by 1891

  - A pressure problem was solved to protect the fragile multi-strand conductors and insulators and in 1927 a 160 kilometer-long cable was strung between Florida and Havana

  - Installation of the first submerged amplifier in 1943

  - Completion of the first deep water system in 1950 between Key West and Havana

  - The first transatlantic telephone cable systems in 1956 from Scotland to Newfoundland. It consisted of twin links with repeaters every 64 miles. Since then submarine telephone cables have become widespread

- In the 1920's multichannel carrier-frequency coaxial telephone cables came into use on land and were soon applied to submarine cables for short distances.

- Other technological developments regarding submarine communication cables have been:

  - Development of polyethylene, the insulant used for all modern submarine telephone cable systems because of its immunity to degradation in sea water

  - Trustworthy transistors

  - Techniques for pre-insertion of repeaters in a cable for cable-laying operation

- Development of bi-directional repeaters

- Improvements in trustworthy solid-state radio frequency circuitry in repeaters which increased the traffic carrying capabilities

o New submarine telephone cable designs were developed:

  - First, conventionally armored cable was developed, but it had inherent disadvantages; construction of this conventional cable of the 50's has disappeared

  - British lightweight represented several departures: steel strength member on the inside; balanced torque design; aluminum coaxial outer member; and smooth tough polyethylene outer sheath

  - American lightweight

o Over the past 30 years over 20 different submarine telephone cable system designs have been developed.

o Circuit capacity has greatly increased over the past 30 years. Brandwidths are now available which permit transmission of 2 or more color television channels simultaneously. The British and Japanese cable industries have developed marine installations of this nature.

o The number of circuit miles in operation has continued to increase dramatically to an estimated 92 million miles in 1980. Circuit miles have more than doubled over the past 5 years.

o Total investment in cable systems have grown spectacularly from $180 million in 1960 to $3.0 billion in 1980.

o Just as spectacular has been the reduction in capital investment from $300/circuit mile in 1960 to $32/circuit mile in 1980.

4. Level of Activity/Current Usage

o The vast majority of submarine cables are used to provide fast transoceanic communications.

o The current world network of submarine communication cables consist of over a million kilometers of telegraph and 200,000 kilometers of telephone cables.

o Today there are over 200 submarine telephone cable links in the world, connecting over 50 countries, and representing an investment of roughly $3 billion.

5. Projected Use/Trends and Technological Forecasts

- Rock trenching machines will be developed to enable cables to be laid in such areas.

- Currently, there are 23 more undersea telephone cable installation systems in the process of being implemented throughout the world, all of which are scheduled to be in service at least by 1983. In addition, there are 5 cable systems in final negotiations, 14 are reaching agreement to construct and 15 more have announced future intentions for a total of 57 new projects.

- In the future new projects will be conceived and executed and some of the proposed projects will be abandoned.

- The optical mode of transmission using digitized techniques shows strong potential for the future and may replace the analog, frequency-division-multiplex systems.

- From the transmission standpoint, a long distance submarine cable system using fiber optics could be implemented today. Several designs for the cable itself, which would be unarmored, are being developed.

- Testing has already been underway for the undersea fiber optics system and the first optical submarine cable systems will be short-hard, which will be forerunners to trans-oceanic systems that will follow.

- Fiber optics communications are at the commercial stage as AT&T has announced plans to construct an $80 million fiber optics system linking Washington, D.C., Philadelphia, New York, and Boston.

- By the end of the 1980's a substantial part of the submarine cable systems network will be optical.

6. Current and Forecasted Geographical Location

- The average depth for cable systems such as for transoceanic communication, mineral recovery and hydrosphere research is from 12,000 to 15,000 feet with some ranging down to 21,000 feet.

- Typical depths for cables used for offshore oil activities on the OCS and for oceanographic data gathering is 900 to 1000 feet. Cables involved in activities on the OCS are subject to greater stretch from forces such as surface movement of platforms.

- Locations of undersea telephone cable systems under contract involving the U.S.

  - St. Thomas, Virgin Island to Venezuel: 570 mile cable to be completed for service in 1980

  - Guam to Taiwan: 1700-mile cable will probably enter service in 1983

  - U.S. to United Kingdom: Transatlantic No. 7; projected for service in 1983

- Offically - announced future plans for undersea telephone cables3

	Assumed Earliest Date
- Florida to St. Thomas	1985
- Guam to Philippine Republic	1985
- U.S. to Europe	1988
- Guam to People's Republic of China	1985

- Currently, submarine telephone cables go from areas under U.S. jurisdiction to Bahamas, Bermuda, Cuba, Dominican Republic, France, Jamaica, Japan, Philipine Republic, Netherlands Antilles, New-Guinea-Australia, Spain, United Kingdom, and Venezuela as well as between 2 locations under U.S. jurisdiction.

7. On-shore Impacts

- Employment and economic development from

  - Cable production plant

  - Construction/deployment of submarine bottom and riser cables

  - Maintenance crews

  - Businesses involved in the enterprise

- However, production of materials will be limited:

  - Special cable production is required for cables suitable for submarine telecommunication use. Only 5 companies in the world out of the hundreds of manufacturers of electrical cables have produced them. Simplex Wire & Cable Co. of Newington, New Hampshire is the only one in the U.S.

- Only a few plants in the world produce submerged repeaters and seacable system terminal station equipment. Electric Company in New Jersey is the only one in the U.S.

8. Driving Forces

- o Advantages over other systems include:
  - Long life
  - Non-radiating: intelligence is confined to coaxial cable
  - High stability
  - Excellent transmission performance
  - Negligible time delay
  - Competitive costs; low support costs
  - Does not pollute the priceless radio-frequency environment
- o Need for increased communications with various parts of the world
- o Demands created by offshore industry expansion

Barriers

- o Vulnerability to physical damage
- o Inflexibility of cable service routes
- o Long time requirement for manufacture of cable and repeaters for a long cable system
- o Only a few specialized plants can manufacture the necessary equipment

Obviating Factors

- o Spatial communications including satellite take procedence over cables

9. Development Process

Administrative:

- o Cables on the OCS must be accurately charted to caution ships not to anchor and to warn trawler and dredges against picking up or cutting the wire.

- o Approval of the Federal Communications Commission is required.

- o A submarine cable project may take 5-6 or more years from the inception to completion.

    1) The agreement to build the system may take 2 or 3 years to negotiate

    2) Invitation for tenders issued only after about a year's work in finalization of specifications

    3) Over a year from the submission of tenders to award of contract

    4) Engineering, production, and installation of a project takes two or more years

- o Planning of a submarine cable project includes:

    - Prediction of traffic loads and of capital and operating costs to determine if feasible; determine location between what general sea-coast locations, political factors may also affect the decision

    - Determination of the choice of sites based on:

        1) Route and site study: research into charts, records and existing data

        2) Site survey: to produce depth contours, diver examination, extraction of cores, and charting

        3) Examination of possible cable system locations

    - Route survey: vessel used with equipment to produce bathymetric profile, measure bottom sea water temperature; charting

System design:

- o System design is undertaken to determine the size and characteristics of the cable. Exact cable length, spacing between repeaters, and number of equalizers are determined.

- In the design of undersea cables, special attention must be given to stresses on cable during overboarding, suspension and implantment and to the ocean environment in general.

o In the design of undersea cables, special attention must be given to: stresses on cable during overboarding, suspension and implantment and to the ocean environment in general.

o Undersea cables emphasize structural strength and associated stresses, and the application of materials acceptable to the sea environment. Undersea cables usually are of the 3 types:

  - Constructed with a center strength member

  - Constructed with an external braid strength member

  - Constructed with helically laid wires forming a sheath of armor

o In the past submarine cables have usually been constructed with external strength members or armor. However, with the development of modern plastic insulation and jacket materials, submarine high frequency communication cables are frequently made of armorless construction even at mid-ocean depths.

o In designing undersea instrumentation cables, the following environmental conditions must be dealt with: hydrostatic pressure, corrosion and biofouling, subsurface currents, bottom conditions, surface weather, and fish bite

o In the past submarine cables have usually been constructed with external strength members or armor. However, with the development of modern plastic insulation and jacket materials, submarine high frequency communication cables are frequently made of armorless construction even at mid-ocean depths

o Repeater and equalizer enclosures must be designed for long submerged life at sea-bottom pressures.

Construction /Repair Requirements

- o Extraordinary insulation

- o In order to reduce the number of accidents to cables from trawlers, ship's anchors and dredges, cable-laying authorities have chartered submersibles with water-jet pumps to bury their cables. Cable burying is usually carried out only from shore to the edge of the continental shelf in depths up to 200 meters.

- o Specially constructed vessels are used to lay submarine cables usually with two propellers aft and one forward to enable them to hold position in rough seas. The hold of the vessel has large vats for storing as much as 4,000 kilometers of cable which is coiled by hand before the ship goes to sea. Linear cable engines are being used. A single cable laying job may last over a month.

- o Should a submarine cable break or deteriorate internally, cable repair ships are used to service the cables. Electrical tests determine the approximate locationl

- o Execution of the project requires:

  1) Preparation of terminal station buildings

  2) Manufacture and installation of terminal station equipment prior to cable laying

  3) Manufacture of cables and repeaters

  4) Loading of cable onto cableship

  5) Paying out cable by cableship to shore with floats

  6) Joining shore end to land cable stretching to terminal station establishing electrical continuity

  7) Laying of cable along prescribed route

  8) Continual testing of the system throughout voyage

  9) Joining at other site by splicing

10. Logistical Support Systems

- o Trenching machines/water jet pumps
- o Cable laying ships: cableships, reel ships, reel barges
- o Cable repair ships
- o Cable production plant
- o Terminal station

OFFSHORE STRUCTURE MISSION CATEGORY: TRANSPORTATION

1. Operational Systems

   1) Pipelines

      a) Gathering lines - connect individual wells to central platforms, usually 12 to 24 inches in diameter.

      b) Flow lines (or transmission lines) connect central platform to shore.

   2) Techniques for laying pipelines offshore

      a) Lay barge technique - most flexible and common technique; sections of pipe, usually coated with concrete, are welded together on board a barge and released into the water being supported by a stinger as the barge moves forward; used for pipes from 4 to 52 inches in diameter.

      b) Reel barge method-long sections of pipe, 12 inches or less, are welded on land, wound onto a large reel on the barge and then laid directly from the reel.

      c) Pipes pulled from shore-pipes, limited between 2 to 4 miles, are pulled from make-up facilities on shore into the water. A similar technique in to fit a pipe with buoyancy tanks onshore, float to location, and then sink and weld it to other sections; this is limited to calm seas and by the high costs for diving operations.1 Another recent method is to two long sections of pipe a few meters above the seabed by the use of buoyant units and chains.

2. General Description of Mission

   o Pipelines serve two major purposes in the oil and gas industry--gathering gas and petroleum fluids and transporting them to shore. Gathering pipelines bring the gas and fluid to a central point for treatment, storage or measuring. Beyond the point, pipelines are called transmission lines and may be shared as common carrier lines, but which a single user may own.

3. Historical Development

   o Marine pipelaying has achieved its advance state of technology as the result of market demands, a changing laying environment and competition.

- Marine pipelaying had its beginning only about 25 years ago

- Reel pipeline concept

  - First deployed during World War II across the English Channel as part of the war effort

  - In the 1960's straightener system was devised to straighten the pipe without damaging it to make this method commercially practical for the oil industry; corrosion protection was also provided

  - In 1970's, a pipelay vessel was designed to spool pipe in depths up to 3,000 feet

4. Level of Activity/Current Usage

- Currently, pipelines are used to transport all natural gas and 98% of the oil produced offshore in the U.S. All known plans within 200 miles of shore incorpoate pipelining.

- Well over 13,000 miles of offshore pipelines have been laid throughout the world.

- Only a few lay barges are capable of laying pipe in up to 1,000 feet depths. Increasing depths reduce overall positioning capabilities of pipelay vessels; also, seafloors and environmental sea major obstacles.

- In 1978 there were 61 pipeline projects in the Gulf of Mexico in various stages of planning or construction. During 1979 the Gulf of Mexico had 600 miles in prospect.

5. Projected Use/Trends and Technological Forecasts

- Pipelines will continue to dominate the transportation of oil and gas to shore for offshore petroleum developoment throughout the forecast period.

- The deployment, use, and function of submarine pipelines will expand over the forecast period.

- Pipelines will continue to have increasing use for offshore oil and gas operations, including offshore ports for transporting petroleum to land-based refineries. Offshore oil and gas extraction activities will experience significant accelerated growth over the next decade alone. Demand for pipelines will be boosted substantially, especially if there are sizeable deposits of oil and gas in the U.S. Atlantic OCS and offshore Alaska discovered.

- Pipelines will be used to interconnect large clusters of drilling wells into one distribution platforms/mooring point for loading onto vessels.

- Oil and gas from wells near to coastal margins will be pumped via pipelines directly to land-based refineries.

- The concept of slurry pipelines will gain momentum toward the latter part of our forecast period and will find notable applications in the offshore environment. Offshore multi-purpose ports and underwater extraction sites seeking to mine coal or other minerals will crush the ore, mix it with sea-water, and transport the slurry to key destination points.

- Development of semisubmersible hulls for pipe lay vessels with articulated stinger will increase their capability to operate in rough weather, but will increase cost.

- Current technical capability of pipelaying suggests that required pipelaying techniques will be developed to meet the demand for deep water production with minimal time lag.

- The collecting lines required for subsea completion systems will represent the maximum depth.

- The deployment of larger pipelines for transporting crude to shore will be constrained by economic feasibility. It will probably not be economical in depths over 1500 feet. Instead tankers will more commonly use to transport the crude from offshore storage facilities to shore.

- Pipeline construction in the near future will not increase considerably worldwide as offshore loading will be used to a greater extent. Spur lines will be used where possible to connect new fields to old lines.

- Pipelaying techniques finding application in deepwater are:

  - Dynamically positioned lay barge

  - Towing an assembled pipeline from shore or shallow water

  - Floating out pipe strings made on-shore to the lay barge using buoys; pipe is welded on the lay barge and fed over a conventional stinger. This system enables the use of a dynamic position system since the barge is physically smaller.

- In sum, the offshore and on land pipeline industry will continue to emerge as one of the most dynamic, fastest growing industries in the U.S. economy, and in certain other parts of the world.

Recent Technical developments:

- Stabilizing bags which are installed on a pipeline by a diver with a surface support craft have been found to be useful in reducing stress on pipes and to stabilize pipes against movement.

- Automatic welding machine.

- An offshore plow has recently been developed to reduce costs, which lays pipe and in the same operation forms a ditch and buries the line.

- The inclined ramps will be an effective method for deepwater work in the future. Pipe sections are transported to the vessel and welding take place on the ramp. As the barge moves forward, the pipe is submerged as tensioners support the free hanging pipe weight. The ramp is hinged to the barge and will adjust to an angle suitable to the water depths and pipe strength. This method eliminates the use of the stinger which has been found to be failure prone.

- An example is the Saipem's Castoro Sei which has significantly extended the state-of-the-art in pipelaying vessels. It has a specially designed inclined pivoting ramp which has been responsible for the vessel's deepwater accomplishments. The moveable ramp enables greater flexibility and accuracy. It has set pipelaying records by laying pipe in 1,200 feet water depths. (Offshore, 5/77). Its next project calls for pipelaying in 2,000 feet depths of underwater gas pipelines from Sicily to Tunisia. This project could further promote transporting hydrocarbons onshore from distant producing fields in deep waters and possibly between continents.

- Santa Fe International Corp. has taken steps forward in deepwater pipelaying in its design of the reel ship, Apache, capable of laying pipe in depths up to 3,000 feet. In order to lay pipe in a broad range of depths an adjustable pipe ramp was needed to enable the pipe to enter the water between 60 and 18 degrees. The Apache is the first self-propelled, dynamically positioned reel ship in the world. eliminating the need for tugs, heavy conventional mooring system, and anchor handling vessels. It uses a computerized position control system which outputs control information to thrusters and main propellers. The prescribed pipelay route is preprogrammed into the pipe routing system.

- Advances will continue to be made in the development of protection monitoring systems for pipelines to prevent structural damage from corrosion and resulting environmental hazards. A recently developed system enables rapid cost-effective checking of subsea anode installation without the need of physical examination by divers or submersibles. This system utilizes

seabed transponders and a single survey vessel.

6. Current and Forecasted Geographical Locations

- See oil and gas production for forecasted areas
- The Gulf of Mexico has one of the most notable gas gathering systems in the world. The Gulf of Mexico has the greatest number of pipelays planned or in progress in the world. Two notable projects occurring in the Gulf include:
  - LOOP project
  - Texas' first major offshore pipelines, a 185-mile gathering system
- An unusual project is the crossing of a Trans-Mediterranean Pipeline that will transport Algerian gas to northern Italy.
- Successful methods and techniques have recently been developed for the tie-in of large diameter pipelines to production facilities in about 500 feet of water by seabed welding.
- An under-ice pipeline installation process has been developed for Pan Arctic Oils Ltd., using a novel bottom pull method with the ice surface as a stable platform.

7. On-shore Impacts

Employment and economic development from:

- Pipelaying operations are very labor intensive, requiring as many as 175 crew members to operate the lay barge, two anchor handling tug boats and two crew boats[1]
- Shore facilities for construction and preparation of pipes; development of local economy

8. Motivating Factors

- Demand for oil and natural gas from offshore fields
- Demand for deepwater ports for supertanker imports
- Economic development and employment
- Lower costs

Barriers

- o Oil pipeline spills--the majority of which are caused by accidents such as anchor dragging. More oil has been released into the marine environment from pipeline spills than all other sources related to OCS developments.
- o Depth of water
- o Weather conditions
- o Inherent high costs of offshore construction

Obviating Factors

- o Offshore loading onto vessels from offshore production
- o Lightering of supertankers
- o Development of alternative energy sources

9. Development Process

Administrative:

- o To reduce oil pipeline spills resulting form accidents from accidents such as anchor dragging, state and federal agencies will have to ensure that pipelines are properly marked on navigation charts and that other uses of coastal waters do not damage them.
- o States can control the location of pipelines within state waters, regulate where they come ashore and establish other necessary safety measures.
- o Local authorities also have a role in OCS development and can block pipelines coming into their areas.
- o Authority for pipelines is currently divided among several Federal agencies. The Office of Pipeline Safety (OPS) of the Department of Transportation and U.S.G.S. within Department of Interior share authority for design standards. In 1976 DOT and Interior signed a memorandum of understanding for offshore pipelines; under the agreement, DOT will regulate standards for all carrier lines from the protuction facilities to shore. DOI as authorized by the Outer Continental Shelf Lands Act grants rights of way for pipelines in ocean waters and sets safety standards for gathering lines within the production field.
- o OPS standards apply to both offshore and onshore pipelines without differentiation. OPS has proposed modification for offshore pipelines.

- The Coast Guard has authority in certain circumstances in regard to its concern over oil pollution, offshore law enforcement, and navigation safety.

- Operation of pipelines is supervised by the Department of Energy.

- DOT and DOI will coordinate inspection and enforcement activities and will share responsibility for research.

Regulatory requirements:

- Require biweekly inspections of the pipeline routes to check for small leaks; aircraft, boats, or submersible vessels can be used for this task.

- Comply with Coast Guard safety requirements for life saving equipment on pipelay ships.

- In water depths of 200 feet or less, all new common carrier pipelines must be buried to a minimum depth of 3 feet according to current Bureau of Land Management regulations. Pipelines in shipping fairways and anchorage areas must be buried a minimum depth of 10 feet. Gathering lines between adjacent platforms are not required to be buried.

- Regulations under certain conditions require continuous line pressure monitoring systems with automatic shutoff valves, regular pipeline inspection for leaks, electrolytic protection against corrosion and special exterior coatings.

- Environmental impact statements may make stipulations for a lease sale such as requiring pipelines to be buried whenever technically and economically feasible.

- To assure pipeline safety regulations may be developed for new technologies including:

  - Pipeline coating standards

  - Welding and weld inspection standards

  - Specifications for pipe materials and sizes

  - Procedures for installing and burying pipes

  - Pipeline inspection devices

- Overall, pipeline regulatory standards in the U.S. have not been stringent in the past, which has resulted in many pipeline oil spills.

Construction requirements:

- The cost for pipeline construction varies depending upon pipeline size and thickness, water depth, and weather conditions. The cost of pipeline recently placed in the Gulf of Mexico was from 2 to 5 hundred thousand dollars per mile.

- Pipe laying operations are highly labor intensive. As many as 175 crew members are required to operate the lay barge, two anchor handling tug boats and two crew boats.

- Typically, one mile of pipeline can be assembled and dropped to the ocean floor per day from 300 foot lay barges. The procedure includes: welding 40 foot sections of steel pipe, coating them with asphalt paste or epoxy resin, bathing the pipelines in concrete and then trailing the assembled pipe over the side or stern.

- After the pipe is on the bottom, a jet sled may be dragged over the ocean floor by smaller barges following the lay barges. Water is pumped through nozzles on the sled to dig a trench into which the pipeline settles[3] Alternatively, dredging may be done to install pipeline in pre-dug trenches. Pipeline burial has become a more common practice than in the past.

- After pipelines are in place on or beneath the ocean floor, they are pressure tested for leaks. Once a pipeline is in service, a monitoring system is employed to compare flow rates throughout the network and check for drastic reduction in line pressure.

- Intermediate platforms with compressors may be required to provide maximum delivery rate.

- Diving operations have become an integral part of the pipelaying operation.

- Divers and support vessels are involved in: tie in of pipelines with mechanical couplings or hyperbaric welding, pipeline burial, and pipeline inspection on a periodic base.

- Pipelay support submersibles are used to provide close monitoring of pipe touchdowns.

- Subsea bells perform installation of pipe supports and video recording at bottom.

- A welding chamber and support module for conducting deepwater pipeline tie-ins and repairs at 1-atmosphere pressure

o Environmental stresses must be taken into account indlucing: climate, waves, currents, tides and winds

o Construction projects include: design and technical supervision, feasibility assessment, environmental studies/ geologic investigation, marine surveys, pipe milk to fabricate and test pipe, application of corrosion and weight coatings, detailed route-engineering of to-be-laid pipeline, pipe trenching, execution of the pipelaying, and testing and commissioning

o Repair operations may need to be undertaken for:

- Dry buckle (water not in pipeline)

- Wet buckle (torn pipe flooded)

10. <u>Logistical Support systems</u>

o Vessels: lay barge, tug boats, crew boats, submersibles/ subsea bells

o Derrick or crane barge for repair work

o Divers and diving support vessels

o Welding chamber; hyperbaric welding equipment

o Platforms with compressors; oil pump

- Helicopters
- Jet pumps/trenching machines for pipeline
- Shore facilities - refineries, storage tanks, and pipe construction facilities

OFFSHORE STRUCTURE MISSION CATEGORY: TRANSPORTATION

1. Opeational Systems: 1) Transshipment ports 2) Artificial islands 3) Mobile ports

2. General Description of Mission

   - To serve as a transshipment terminal for bulk materials

   - To minimize ship traffic congestion at established coastal ports and their approaches

   - Accommodation of deep draft vessels including very large crude carriers

   o The emergency mobile port package is designed to provide the capability of unloading essential civilian and military support cargo to meet the operational requirements for two types of situations.

     - Short-notice emergencies including natural disasters, accidents, military attack on the U.S., or a temporary port operation in an undeveloped part of the world

     - Long-term emergencies including extended military logistic operations, long periods of port rehabilitation, and to provide additional capacity at an overtaxed existing port

3. Level of Activity/Current Usage

   o An artificial island has been recently built 8 miles off the coast of Brazil near Areia Branca as a transshipment terminal for solar salt and other bulk materials for shipment to southern Brazil or for export

4. Projected Use/Trends and Technological Forecasts

   o There are currently no plans in the U.S. for transshipment ports as current costs do not favor them as yet

   o By the turn of the century as many as 6, and perhaps more, multi-purpose offshore ports will be under construction or at the planning stage in U.S. territorial waters

- An offshore loading system has recently been designed in which a semi-submersible, equipped with a thruster power riser connector, tows a tanker into position. The "semi" connects with the riser and pumps the oil into the tanker.

- Floating and fixed pile structure and design will become economically feasible for bulk cargo unloading and loading. Large container ships are likely to unload their cargo on these platforms for loading onto smaller vessels for further distribution to U.S. coastal and inland ports. They will also be an unloading point for U.S. exports, later to be picked up by supercargo carriers for distribution worldwide.

- Multipurpose pipelines will be connected to these offshore port centers. Mineral/ore crushing facilities will be located on the platform to crush imported ores into slurry for national distribution via pipeline. Crushing facilities will also be located at a land-based end points to turn exported ore into slurry for transport through the pipeline to the offshore site for loading.

5. Current and Forecasted Geographic Locations

- Near large coastal cities, marine traffic difficulties and overcrowded port facilities will develop.

6. Motivating Factors

- Reduce turn-around time and hence reduce operating costs

- Increasing demand for greater trade levels, both domestically and internationally

- Growing congestion of shipping lanes, channels and harbors

- High density of port handling facilities

- Increasing numbers of accidents including:

  - Ships with pollutant or chemically harmful substances

  - Land-based handling facilities and support personnel

- Shallow harbor depths restrict large ships from entering

- Significant back-ups in vessel loading and unloading operations causing uneconomical delays

Barriers

- o Current costs do not yet favor construction of transhipment ports

7. Logistical Support Systems

- o Supercargo carriers
- o Light vessels
- o Pipeline
- o Port management personnel

OFFSHORE STRUCTURE MISSION CATEGORY: TRANSPORTATION

1. Operational Systems: A. Deepwater Ports. B. Single Buoy Moorings C. Monobuoy Lightering port; basic types of deepwater ports are: 1) Single Point Mooring 2) Conventional or Multi-Buoy Mooring 3) Sea Island 4) Conventional Pier Structures.

A. Deepwater ports (DWP): in general, operations at DWP involve berthing of very large crude carriers (VLCC), restraining them, loading and unloading the tankers, and pollution control.

- o Deepwater ports include a pumping station to force the crude through pipelines to shore. For SPM, pumping stations may be mounted on structural-steep platforms fastened to the sea floor with pilings similar to those supporting offshore oil platforms. One or more decks would be mounted to support pumps, crew quarters and a helicopter pad. Pumping stations would be located on adequate distance from the monobuoy to reduce danger of it being hit by a tanker entering or leaving port.

- o Pipe laying operation from port to shore is identical to procedure used for OCS oil and gas production.

- o Tank forms for deepwater ports will typically store 10 times the port's daily capacity to assure a continuous supply of crude to refineries, even if the port is temporarily closed down.

- o Description of type of deepwater ports:

  1) Single Point Mooring Systems (SPM)--in general, a berthed vessel is moored with bowlines only to a single point around which the vessel can rotate 360 degrees, permitting the vessel to align itself to head into wind, wave and currents to reduce mooring stresses. It requires adequate clearances for safe approach from all directions. There are three types in current use.

     a) Catenary Anchor Leg Mooring (CALM)--the mooring buoy is circular in design and 30 to 50 feet in diameter, it is tethered to the sea bottom by six to eight anchors and chains which permit the buoy to float freely on the surface of the sea. Rubber hoses, which are connected to a buried pipeline, rise through the center of the buoy and float

on the clean surface. Tankers are tied up to the buoy and the hoses are secured to discharge manifolds of the tanker. Crude is then pumped through hoses, and into the pipeline to storage tanker onshore. Over 90% of existing single buoy moorings are of this type, which has been in use since 1959.

b) Single Anchor Leg Mooring (SALM)--a relatively small mooring buoy anchored to a mooring base on the sea floor with a single anchor leg under constant tension. The product distribution swivel is mounted well below the loaded draft of the maximum size tanker for which the terminal is designed. SALM was developed to make safer the CALM system and was first installed in 1969.

c) Single Point Mooring Tower--the berthed vessel is moored with bowlines to a point located on a tower structure fixed directly to the sea bottom.

2) Conventional or Multi-Buoy Mooring (CBM)--a CBM system consists of a number of mooring buoys arranged in a pattern around a manifold anchored to the sea bed. The manifold is connected to the ship by hoses and to storage facilities by a submarine pipeline. The ship is held in a relatively fixed position over the submarine manifold by its own anchor and the mooring buoys. As a result the ship will not weathervane and will experience large motions under heavy broadside sea conditions.

3) Sea Islands--a series of interconnected, fixed structures located offshore and connected to the storage facilities by a submarine pipeline. A loading platform is at the center of the island which supports loading arms that connect the ship's manifold to the sea island manifold which is connected to the submarine pipeline. Breasting dolphins absorb the kinetic energy of the berthing ship and are usually equipped with quick release hooks for spring mooring lines. The ship's mooring lines are connected to mooring dolphins. Since a sea island mooring facility holds a ship in an even more fixed position than a CBM, the ship is susceptible to heavy broadside sea conditions with high stress on breasting berth structures and mooring fixtures.

4) Conventional Pier Structures--either a continuous structure or a series of fixed structures similar to a sea island. Its basic distinction from a sea island is that the pier is connected to shore via a trestle which supports the pipelines and roadway.

B. Single Buoy Moorings--oil is loaded at an oil field after it is initially processed on the platform; oil is pumped to the mooring from the platform by pipeline. The mooring is anchored to the seabed and equipped with a hose which carries oil from a seabed pipe through the buoy to an outlet above the surface. Tankers moor to a swivel at the top of the buoy which enables them to rotate 360 degrees. A floating hose carries the oil from the buoy to a tanker.

C. Monobuoy Lightering Port--used for mooring supertankers while offloading cargo into smaller tankers or barges for transport to refineries rather through pipelines.

2. General Description of Mission: To facilitate the transportation of crude oil in an economical and an environmentally safer way. It permits the use of very large crude carriers which require deeper water. Enabling fewer trips with the potential of reducing costs. Deepwater ports may utilize submerged pipelines which can reduce environmental risks.

Deepwater ports are developed to provide feedstock for refinery capacity in a given region; their use is dependent upon refinery demands. Deepwater port development follows from expanded refinery capacity not vice versa.

Other products, including coal and ore slurries, can be and are proposed to be transported via offshore terminals.

Deepwater port development is not justified for transferring refined products because they are widely distributed through small, scattered terminals and the present transport system is geared for the use of smaller tankers.

Single-buoy moorings are used by tankers to transport oil to shore when the flow of oil from field is not sufficient to justify pipelines installation. Oil is loaded at the field after it is initially processed on the platform.

3. Historical Development

Deepwater Ports:

Development of deepwater ports was triggered by the temporary closing of the Suez Canal in November 1956. Use of the Suez Canal limited the size of tankers transporting petroleum from the Persian Gulf to northwestern Europe and the U. S. East Coast. Since the close of the Canal, the tanker fleet had to be expanded in order to meet the demand. Economics dictated that larger tankers be constructed since the Suez Canal no longer was an influencing factor. In the late 50s, port/harbor facilities capable of handling "super tankers" became a critical factor.

In northwest Europe in the early 1960s, economic factors including the accelerated demand for petroleum necessitated the use of larger tankers. The chief barrier to the development of ports to accomodate deep draft vessels was the high cost of deepening harbors or extending ports into deeper water. Two simultaneous developments provided a new approach: 1) development of techniques for laying large capacity pipelines in deep water; and 2) development of a system for loading and unloading deep draft tankers utilizing underwater pipelines to transport crude oil to and from tank storage facilities on shore. The single point mooring used for this purpose came into accepted use in the mid-to-late 1960s.

Since the late 1960s interest in the development of deepwater ports has increased rapidly in the U.S. Between 1950 and 1970 U.S. oil imports nearly tripled. With the growing dependence on super tankers in the world distribution system, U.S. officials and industry pressed for deepwater ports in U.S. waters to handle the fast growing imports. With the enactment of the Deepwater Port Act in 1974, a number of projects were organized; two applicatioons for deepwater ports were approved by DOT in December 1976 (SEADOCK and LOOP). LOOP is near completion of construction, but SEADOCK chose not to accept the license offer because of problems with government specifications. Since then, Texas Deepwater Ports Authority of the state of Texas has submitted an application to DOT for a license as an amendment to SEADOCK's previous application. The basic plans for the physical facility are the same. The only change is in the institutional aspects of ownership and financing. DOT has approved the license, but TDPA has not yet accepted as it still has financial arrangements which need to be made. The public ownership by TDPA alleviates to a large extent the antitrust concerns which faced the original SEADOCK application.

Mooring System Projects

The first crude loading and unloading terminal away from land was in 1959 off Sweden. Between 1970 and 1975, an explosion occurred in the rate of building new terminals as 123 units were positioned. Most of these systems prior to 1974 were transfer terminals for exporting or importing crude oil. After that, new systems were designed for rougher conditions and deep water and were linked to production platforms or to subsea systems. This enabled earlier and more economical production. In just the past several years, floating or bottom-attached units have been permanently linked to tankers for storage and surge.

4. Level of Activity/Current Usage:

- o Currently, the U.S. does not have any offshore deepwater port facilities

- o There are about 22 major offshore loading/unloading port facilities of the fixed pier or mooring buoy types locates with the three-mile state territorial limit, most of which are off California and a couple off Hawaii. At lease 13 of the facilities in California territorial waters are mooring buoy types with submerged pipeline connections leading to shore. Some of these units have been in operation since World War II without any major oil spill accidents

- o Currently, 142 SPMs are in operation or are planned worldwide. The Catenary Anchor Leg Mooring System is the most common

- o U.S. is the only major oil importing nation which cannot accomodate super tankers

5. Projected Use/Trends and Technological Forecasts

Although deepwater ports are an environmental and economic sound way to import crude oil, the high interest in using them recently has diminished. The U.S. national energy policy to lessen our 'dependence' upon imported crude oil will cause the percentage of oil we import to decline substantially during our forecast period. As a result the demand for new deepwater port construction projects will continue to diminish.

A number of different groups have initiated proposals for the identification and construction of possible deepwater ports in the U.S. Thus far, LOOP has accepted a DOT license and is constructing a deepwater port in the Gulf of Mexico. LOOP is 75-80% complete and is expected to be operational in February 1981. The Texas Deepwater Ports Authority has been offered a license in place of the SEADOCK project, but it has not yet accepted.

Other factors have reduced the demand for deepwater ports. Along the East Coast, limits on refining capacity have minimized the need for deepwater ports. The refining capacity is not expected to increase much in the future. On the West Coast, there is deep water close to shore which alleviates the need. Environmentalists and state and local concerns have also been a barrier to deepwater port development. Compliance with Coast Guard requirements and licensing further slows the development.

Two techniques have provided a substitute for deepwater ports; transshipment by onshore facilities in the Bahamas and Netherlands Antilles, and lightering into smaller tankers.

Following the completion of LOOP and possibly a project by the Texas Deepwater Ports Authority or a replacement project, we expect at most only a couple if any deepwater port projects in the foreseeable future.

The single point mooring system will most likely be the type of system used in any future projects off the U.S. coasts. It is a proven technology, less expensive, safer and more accessible in rough weather than other designs Multinational oil companies can transfer the technology to U.S. sites.

The SPM terminal many find future application with floating LNG plants on barges, as well as with process plants, desalination plants and power generation facilities. A buoyant tower structure with a dual cargo piping system within that connects from the mooring base to a seabed pipeline has been suggested for an LNG barge.

SPM Terminal for Permanently Moored Tankers

There has been a recent trend toward the integration of subsea completions for offshore production with a permanently moored floating storage tanker which can be designed with production capabilities on board. A SPM terminal would be required. One method has been the use of an articulated yoke enabling the passage of high pressure production fluids from subsea completions to a permanently moored storage/production tanker.

A Storage Production Terminal has recently been designed, without the articulated yoke, which uses a swivel turret, rigidly attached to the dedicated storage production tanker. This system can be used respectively at other fields.

With the emphasis on smaller fields in offshore deveopment, making the fixed pipeline and platform approach uneconomical, the trend toward this type of system should continue in the world. The surplus in tankers in recent years has stimulated this system.

6. Current and Forecasted Geographical Locations

- o Deepwater ports which haad licenses approved by DOT were:
  - LOOP Project: conceived of in 1972, calling for the construction of a deepwater port complex 26 miles off Louisiana. Nine partners are involved in the venture which is currently 75-80% complete. It should be operational by February 1981. It is essentially a monobuoy system.
  - SEADOCK Projects: an abandoned effort by a consortium of oil and petrochemical companies which proposed to construct a deepwater port off Freeport, Texas.

- Texas Deepwater Ports Authority - basic same physical plans as SEADOCK. Consists of a mooring and pumping facility located in the Gulf of Mexico 26 miles from Freeport and an onshore terminal 4.5 miles inland. Offshore facilities consist of 4 single point mooring buoys 7,000 feet apart, a pumping platform and or quarters platform. The SPMs will be connected to the pumping platform by one 52 inch diameter pipeline. Two 52 inch diameter lines will link the pumping platforms to shore.

- Delaware Bay Transportation Company, involving a consortium of 15 major oil companies, originally planned a 3-berth fixed pier five miles off Big Stone Beach inside Delaware state waters in Delaware Bay. However, this project was tied up by an unfavorable political climate in Delaware.

- The Coastal Plains Regional Commission of the Southeast has recommended 3 feasible deepwater port sites in 110-feet of water ranging from 15 to 40 miles offshore

- In California, the development of offshore deepwater ports is variable due to changes in jurisdictions of various agencies. An offshore deepwater port has been proposed at Morro Bay in San Luis Obispo County with monobuoys located just inside the three-mile limit.

- The states of New Jersey, Maine, Massachusetts, and Washington have been investigating the potential of deepwater ports.

o According to a DOT report, a deepwater port is not likely to be constructed to serve the Mid-Atlantic in the immediate future. If a deepwater port were constructed, it would probably be a monobuoy port off south New Jersey. However, import projections are low and industry has only a low interest in a Mid-Atlantic port.

o The Corps of Engineers has issued a permit to the Virgin Islands Refinery Corp for a monobuoy facility to be located 2 miles off St. Croix.

7. <u>On-shore Impacts</u>

o Requires onshore support facilities

- Tank farm

- Waterfront land required for staging of construction crew, and equipment, repair, pipeline supply, headquarters operation, and dock for work and supply boats

- New refineries may eventually need to be built
- Industrial development and business activity providing more jobs and economic stimulation
- Losses to the tourist recreation industry and damaged beaches

8. Motivating Factors

- Environment and safety advantages over present methods
  - Fewer spills
  - Less tanker traffic in rivers and ports
  - Fewer collisions, port fires
- Under certain conditions--economic advantages
  - Cost savings for transporting oil to U.S.
  - Stimulate economy
  - Industrial development
  - Tax revenue
  - Increase employment
- Increase energy availability
- Lower energy costs
- Technology already developed
- Lack of sufficient depths at most ports to accommodate the new generation of very large crude carriers

Barriers

- Energy self-sufficiency
- Environmental concerns
  - Risk of catastrophic spill from supertanker
  - Pipeline ruptures
  - Environmentalist opposition

- o Limited growth in refinery capacity on East Coast
  - State policies/regulations discourage new refineries
- o Major financial investment required
- o Inflated costs in offshore construction; lightering or alternative systems cheaper
- o Uncertainty of foreign oil supplies
- o Tax policies against oil imports; import quotas
- o State rejection/postponement of proposed deepwater port porjects
- o Negative onshore impacts--damaged beaches; industrial development
- o Economic disadvantages
  - Loss to recreation industry
  - Balance-of-payments
- o Antitrust concerns

Obviating Factors

- o Development of alternative energy sources, such as solar, coal and nuclear
- o Development of domestic OCS oil production
- o Alternative methods for oil importing

9. Development Process

a. Administrative/regulatory

1) Within territorial seas

- o All deepwater ports within 3 miles of shore come under jurisdiction of the U.S. Army Corps of Engineers, of the States, and of any regional commissions or authorities authorized by States. If a State has laws regulating deepwater ports, the Corps will issue a permit only if the Stater approves
- o A State may effectively exercise authority through its coastal zone management program, which may act as the

lead agency in processing the proposed project and in coordinating various agencies involved including the Corps of Engineers and the Coast Guard. It may choose to pattern its regulations after the Deepwater Ports Act.

- o Coordination between the Army Corps of Engineers and DOT has been minimal with respect to deepwater ports in state waters. The Corps is not required to set the same standards for consturction and operation set by DOT.

2) Outside of territorial seas

- o Under the Deepwater Port Act of 1974, DOT has the responsibility for coordinating and licensing deepwater port projects beyond the territorial sea

- o Comprehensive Coast Guard regulations have been written for the construction and operation of deepwater ports along with proposed guidelines for developing design criteria for specific sites, for environmental impact statements, and for operating procedures

- o The Deepwater Port Act and the regulations promulgated under its authority establish a comprehensive review process for each project

  - Established a 45-day review process during which coastal states may comment upon the project

- o License process

  - Preparation of a detailed application including information specified in the rules and regulations

  - Reviewed by states, federal agencies, and interested members of the public

- o State role under the Deepwater Ports Act

  - If a coastal state intends to construct a deep draft channel and harbor, then DOT cannot grant a license until it evaluates the relative benefits of each alternative and consider if they are compatible

  - At least one public hearing will be held in each state designated as "adjacent"

b) Construction Requirements

- o Deepwater ports serving the largest tankers which are 480,000 dwt would need to be constructed in depths of at least 110 feet to enable tankers to maneuver

- The small risk of a catastrophic spill from a supertanker dictates the use of pollution control and cleanup systems at deepwater ports

- DOT regulations require DWP operators to have onsite equipment for containing and cleaning up spills of less than 1,000 barrels. Equipment for dealing with larger spills needs to be readily accessible to the opoerator

- After licensing, considerable time is required to construct the offshore portions of a deepwater port. Two years was the estimated time for a Mid-Atlantic site for construction of the offshore portions

- A variety of security measures are necessary at deepwater ports. One measure taken at LOOP is the stationing of U.S. Coast Guard personnel

10. Logistical Support Systems

- A certain number of ancillary vessels are required for berthing very large crude carriers at deepwater ports

  - Single Point Mooring and Conventional Point Mooring require 2 line-handling launches and 1 rug (possibly)

  - Sea Islands and Pier Structures require 2 tugs

- Each deepwater port in the U.S. needs at least one vessel equipped to handle and contain oil spills and equipped with fire fighting apparatus

- Coast Guard Vessel Traffic Surveillance System - required for deepwater ports in Federal waters; similar to an air traffic control system

- Pipeline from port to shore

- Onshore facilities for:

  - Tank farm

  - For staging of construction crew and equipment, repair, pipeline supply, headquarters operation, and dock for work and supply boats

- Adjacent coastal states can fix reasonable fees for the use of a deepwater port facility and for the use of land-based facilities related to the deepwater port facility.

- An adjacent coastal state to which a deepwater port is connected by pipeline must develop an approved coastal zone management program.

- DOT cannot issue a license without the approval of the governor of each "adjacent" coastal state. Also, the governor can identify aspects of the project which are inconsistent with its programs in which case DOT can make granting of the license conditional upon alternations of the project.

- Adjacent states receive priority over private applicants to construct and operate a port.

o Under Federal law the Coast Guard is required to install a traffic surveillance system for deepwater ports in Federal waters, but is not required for State waters.

APPENDIX TO CHAPTER 8 OF VOLUME II -- RECREATION/CONSERVATION

OFFSHORE STRUCTURE MISSION CATEGORY: Recreation/Conservation

1. Operational Systems: Artificial island/marshes/land extensions; breakwaters/groins; beach rehabilitation; sand bypassing to prevent erosion.

2. General Description of Missions:

- o Artificial islands and extension of the land constructed by dredge and fill operations can be used by a variety of recreational purposes, including: marinas, beaches, fishing, hotels and camping.

- o Artificial marshes resulting from dredge and fill operations can provide attractive fishing sites.

- o Groins are constructed of timber, steel, concrete or rock structures perpendicular to the shoreline across the beach and into the water. They trap sand moving along the shore and widen the beach in that location.

- o Offshore breakwaters are massive, usually rock structures, constructed in the ocean parellel to the shore. They prevent waves from reaching the shore, and resulting in reduced shore currents and accretion behind the structure. This conservation method provides protection without changing the form of the beach and provides sheltered waters for boating and fishing.

- o A variety of techniques can be used for beach rehabilitation and development.

  - A hopper dredge, which is self-propelled, self-sufficient, hydraulic dredge plant, can be equipped with a direct pump-out facility to pump sand onto an ocean beach from an offshore mooring.

  - A cutterhead dredge can be used offshore in conjunction with a floating pipeline attached to the discharge pipe of the dredge and through which the sand is pumped and discharged on the beach.

  - Trapping sand with a dam-like structure and recycling it by fixed installation pumping upcoast.

  - In order to construct and maintain a beach, sand lost downcast as litoral drift can be compensated for by: a stockpiling procedure, continuous nourishment, direct placement or by an offshore deposit.

- Sand bypassing of natural or man-made inlets by artificial means can be done to prevent erosion down beach of the inlet.

3. Historical Development:

4. Level of Activity and Current Usage:

- Land extensions, such as Miami, have been developed which have made an enormous contribution as a resort area of recreation.

- Land reclamation of dredging methods has been accomplished in other parts of the world. A notable operation occurred at Monaco where land was reclaimed from a substantial water depth by the construction of an offshore dam and the use of hopper dredge.

- Numerous groins and breakwaters have been constructed for conservation/development of shoreline areas.

- Several notable activities have been undertaken in the U.S. for beach rehabilitation.

  - The Coastal Engineering Research Center conducted a program to locate and delineate offshore sand deposits suitable for beach restoration.

  - The Corps of Engineers used a hopper dredge to place offshore sand deposits on a New Jersey beach.

  - The California Department of Water Resources has investigated possible plans for replenishing the beaches of California, which have been facing an erosion crisis.

  - Jupiter Island, Florida undertook a beach repair, stabilization and nourishment project as the result of a North Atlantic storm which caused the 16-mile island to be battered with swells. Skin divers investigated offshore sand deposits with metal rods to determine sand depth. Jupiter Island obtained bids from contractors to place sand on the beach from offshore borrow areas. This method obtained superb results.

  - A cutterhead dredge was used for offshore dredging in a Florida beach replenishment project.

- Two sand bypassing methods which have been employed are:

  - A fixed bypassing installation with a pumping station; the best known in the U.S. is at Lake Worth Inlet, Florida, which was installed in 1937.

  - India has employed a dredge pump installed on a traveling platform with a swinging, crane-supprted suction cup. The platform travels on rails the length of a concrete pier and dredging can be done along both sides of the platform.

5. Projected Uses/Trends and Technological Forecasts:

- Only one-third of the national seashore has beach areas; 70% is privately owned and not available for public use; and erosion is causing the shrinkage of many beaches.

- In view of this, it can be expected that there will be increased usage of groins and offshore breakwaters for protecting beaches and techniques will improve. These techniques will be useful also in the development of small boat harbors and will have secondary benefits for marine recreational fishing.

- Similarly, the need for more recreational beaches, particularly in coastal urban areas, will drive the construction of artificial island neat to the coast by the use of dredging techniques. They may be connected to land by a causeway or footbridge. Current shorelines also will be extended through the creation of artificial peninsulas.

- A National Shore Study in 1971 conducted by the U.S. Army Corps of Engineers showed that critical erosion occurs at some 27 miles of shoreline nationwide; of which 1220 miles is likely to soon endanger life, public safety, property, wildlife habitats, and historical landmarks. The study recommended the use of artificial fill with periodic nourishment to restore and preserve a beach as the preferred method.

- Offshore sand will have to used for beach nourishment because most inland sand sources have beeen exhausted and environmental considerations prevent their use. Several projects all over the world have demonstrated that it is feasible and economical to use offshore sources. Sand from offshore borrow areas will be used at numerous locations in the U.S. in the near future for beach nourishment.

- New designs for the sea-going hopper dredge or the cutterhead dredge will likely be developed specifically for the economic rehabilitation of ocean beaches.

6. Current and Forecasted Geographical Locations:

- Artificial islands which have been constructed for industrial purposes are being considered for multiple use in recreation off California.

- It is imperative that action be taken to prevent the erosion crisis faced by California's beaches. At least one of the following alternatives will be taken:

  - Supplying sand to the beaches from dredging offshore.

  - Trapping sand with dam-like structures near the head of submarine canyons and recycling it by fixed installation pumping upcoast.

  - Construction of elongated islands running parallel to existing beaches, forming lagoons

  - Sluicing stream-borne sands past flood control basins

7. Development Process:

- River and Harbor Act (46 Stat. 945 (1960), 33 USC 426)- authorizes the Corps of Enginers to help States and local governments control public coastal beach erosion.

- Federal Water Pollution Control Act Amendments- established a dredge/fill permit program administered by the U.S. Corps of Engineers in order to help restore and maintain the quality of U.S. waters through regulation of release of pollutants.

- State and especially local governments have recently been given a larger role in the protection and development of wetlands.

Motivating Factors	Barriers
o Demand for more recreational beaches; overcrowded beaches and recreational facilities, particularly in coastal urban areas, diminishing the quality of the experience.	o Lack of knowledge as to possible adverse environmental effects of conservation techniques.
o Conservation of our eroding recreational beaches.	o Depletion of sand supply for beaches down current
o Protection against the erosive destruction of costly coastal real estate.	o Costs incurred in undertaking conservation projects
o Provision of allocation for disposing of dredged materials from harbor or channel dredging	o Lack of availability of right type and sufficient quantity of sand for beach fill operations.
o Development of harbors for recreational boating and fishing	o Lack of access to the shore by the public; problem of private ownership of coastal areas.
o Development of a local economy; profit	o Regulatory compliance
	o Shortage and cost of gasoline for traveling to the ocean and using boats
	o Conflicts of sea use/areas

OFFSHORE STRUCTURE MISSION CATEGORY: Recreation/Conservation

1. Operation Systems: Artificial reefs/offshore platforms. Artificial reefs or fish havens are constructed by dumping assorted junk, such as old trolley cars, barges, scrap building materials, tires, old automobile bodies, and ship hulls, in areas which may be of small extent or which may be of small extent or which may stretch for a considerable distance along a depth curve.

For description of offshore platforms see oil and gas production.

2. General Description of Mission: Fish havens or artificial reefs are established usually for sport fishermen to stimulate natural reefs and wrecks which attract fish. These reefs have been found to accumulate significant populations of reef-dwelling species that are desirable to commercial fishermen, sport fishermen, as well as scuba divers.

Offshore platforms, which are constructed for the purpose of oil and gas production, stimulate marine life and attract sport fish. Hence, they are attractive sites for sport fishing, scuba/skiing diving, and spear fishing.

3. Historical Development:

4. Level of Activity and Current Usage: Development and usage of artificial reefs has become a common practice off the coasts of the U.S.

5. Projected Use/Trends and Technological Forecasts: Development and usage of artificial reefs will increase at an accelerated rate during the next 25 years. Reefs will be created as a means of disposal of an increasng amount of junk from coastal cities, old automobile bodies, and ship hulls from our aging fleet. Artificial reefs will help satisfy the increasing demand for recreation in view of increased leisure time and disposable income.

Offshore platforms will be increasingly used as sites for sport fishing and scuba diving, particularly as the number of offshore platsforms for oil and gas development increased. In addition, over the next 25 years offshore platforms and semi-submersible mobile platforms, which reduce the impact of wave action, will be developed for the primary purpose of marine recreation. Their multiple uses may include: sport fishing, sport diving pads, underwater view chambers, rendezvous points or havens for scuba divers and skin divers, and as navigation aids.

Surveys indicate a great increase in recreational fishing in the past. This trend will continue to the end of this century. This will provide a strong incentive to develop attractive fishing areas. Currently, there are roughly 30 million marine recreational fishermen in the U.S. As shorelines and fishing piers become increasingly over crowded especially in metropolitan areas, diminishing the enjoyment of fishing, there will be a strong demand to establish attractive areas offshore for fishing.

Artificial reefs may possibly find an application in enhancing surfing wave conditions. Research modeling has been done on this prospect.

6. Current and Forecasted Geographic Locations: Numerous fish havens are presently located along the Gulf coast and along the U.S. Atlantic coast, particularly off northern Florida and southern Georgia. They are usually located at a depth of less than 100 feet.

Offshore platforms, constructed for oil and gas development, are located in the Gulf of Mexico and to a much less extent off California. Offshore platforms constructed for oil and gas development, are located in the Gulf of Mexico and to a much less extent off California. Offshore platforms in the Gulf of Mexico

have become favorite sites for spear fishing, diving and sport fishing. The California Coastal Commission has recommended the multiple use of near-shore platforms for recreation. Over the next 25 years there will likely be offshore platforms constructed for oil and gas development in other areas of the U.S. OCS, such as off the U.S. east coast and off Alaska, which will be used in marine recreation. Platforms will be constructed specifically for marine recreation near large coastal cities which have limited and over crowded shoreline recreational areas.

7. Onshore Impacts: As a result of the wealth-transfer effects created by the development of artificial reefs, the cost and benefits will vary depending upon the identity of the groups. Businesses in areas nearby which compete with the area having the most convenient access to the artificial reef may suffer loss in earnings. Federal and state governments may incur costs in giving money or materials to be used for reef development. Although benefits to the economy local to the reef may be offset to a large extent by negative effects outside the area, the negative effects tend to be diffuse.

The development of artificial reefs has a wide range of positive impacts to the local area. Recipients of the benefits include: charter boat businesses, bait and tackle dealers, gasoline dealers, ice dealers, the motel industry, retail food and drink establishments, and restaurants to name a few. Through respending, it is possible for people in all segments of the local economy to benefit from the development and use of artificial reefs. Hence, they can have an important role in the development of a local economy.

Similar effects can be expected for offshore platforms.

8. Primary Motivating Factors/Barriers/Obviating Factors: The principal motivating factor behind the development of artificial reefs and platforms for re-

creation is the enhancement of the opportunities for sport fishing and diving. Secondary factors include: development of a local economy, improvement of commercial fishing, increased food supply,and means of junk disposal.

The chief barrier is the costs involved in developing an artificial reef or constructing a platform. Costs for developing artificial reefs include the cost of acquiring, transporting, and sinking junk. Another barrier is the area required and the restrictions imposed upon other marine activities. In the cast of offshore platforms used for oil and gas, there will be certain restrictions made for the safety of human life.

9. Development Process: Administrative/regulatory- Before a reef may be built, a permit must be issued by the Corps of Engineers, specifying the location, extent and depth over the reef.

Public/private institutional relationship- Fish havens are usually established by private interests, usually sport fishermen. However, in some cases the federal and state governments may be involved in developing and maintaining artificial reefs. For example, the federal government donated ship hulls which could have been salvaged to the states of Alabama and Mississippi. These states also incurred costs in developing the reefs.

Construction requirements: For artificial reefs a wire drag must be used to ensure that permit specifications for depth are adhered to. Also, buoys are marked and maintained.

10. Logistical Support System:

1) Boats: charter, personal, commercial fishing vessels, tug

2) Onshore support: bait & tackle dealers, gasoline dealers, etc.

OFFSHORE STRUCTURE MISSION CATEGORY: Recreation/Conservation

1. Operational Systems: Underwater chambers, offshore hotels/restaurants; and marine recreation in general.

2. General Description of Missions:

   - Underwater chambers (an extension of the idea of marine lands and aquariums) could be used to observe kelp gardens and marine life as well as famous wrecks. They could be fixed bottom structures or they could be tourist types of submersibles which take an excursion through the deep in a specified area. Offshore platforms might be used in conjunction with underwater chambers for boats to use in transporting tourists from and to shore.

   - Innovative restaurants may be developed on offshore platforms or even as underwater chambers for tourists to enjoy unusual marine life.

   - Offshore hotels can serve as novel vacation resorts in addition to providing living quarters for those working on offshore oil rigs. They could be particularly attractive for sport fishing, diving, boating and entertainment. They could be constructed on artificial islands, on land extensions, on offshore platforms, or on pillars; or they may be famous ocean vessels permanently stationed near shore for tourists.

3. Historical Development:

4. Level of Activity and Current Usage:

   - Currently, there are no underwater chambers/restaurants being used off the U.S. coasts for recreation.

   - Offshore hotels have been constructed on offshore platforms. These may be equipped with recreational facilities, such as a movie theater.

5. Projected Uses/Trends and Technological Forecasts:

   - In view of increasing leisure time in America, an increase in disposable income, and the lure of the marine environment for a variety of recreational pursuits, marine recreation as a whole will continue to grow at a high rate.

- By the year 2005 there will be numerous marine parks and marine sanctuaries designated and stringently protected in U.S. territorial waters. Marine parks may deploy some offshore structures such as offshore platforms.

- Due to the nature of recreation in which new kinds can quickly emerge and mushroom (such as surfing, hang gliding, dune buggies), it can be expected that new forms of marine recreation not yet feasible or considered may emerge and rapidly grow.

- Unusual marine recreational structures installed in the ocean for tourists to enjoy marine life, such as underwater chambers, under waterwater restaurants, and offshore hotels, will emerge off the U.S. coast during the next 25 years, but will be few in number. They will be privately owned and operated and will be expensive.

- Through the turn of the century there will be an increasing amount of multiple use of offshore structures. Artificial islands and offshore platforms will be used for industry and recreation. Underwater chambers will be used for recreation as well as for research purposes. Offshore barriers will be used for beach development and fishing.

- As our knowledge of the marine environment and technologies used in exploiting it rapidly grow, they will be transferred for marine recreation applications, facilitating its growth.

- Marine recreational fishing is projected to continue growing at a fast rate in the future. The number of salt water fishermen is expected to triple over the next 25 years.

- It has been estimated that total ocean-related economic activity for outdoor recreation in 1972 was 5.2 billion dollars ($4.1 billion for consumer expenditures and $1.0 billion private investment). This was projected to more than double by the year 2000 in 1972 dollars to about $12 billion. However, this includes secondary land-side expenditures such as transportation, food and lodging costs incurred, which represents the largest part of consumer expenditures. Direct consumer expenditures for ocean-based recreation (which includes fees and charges for ocean access, boat rentals, etc.) was projected to more than double to between $1.26 and $2.00 billion dollars in 2000.

6. <u>Current and Forecasted Geographical Locations</u>:

- Most marine recreational structures will be constructed near or from shore in relatively shallow depths. In order to alleviate

the over crowded conditions of beaches and recreational facilities in coastal urban areas, offshore structures will be most intensively constructed in these areas where they are most greatly needed.

- In order to alleviate the space problem encountered by recreational boating for keeping boats, boat storage will be provided on islands, offshore platforms, and floating structures.

- Underwater chambers of some type for viewing marine life will be located in especially scenic areas such as off Florida or California.

- Offshore hotels might be constructed in waters which are not too rough, such as in bays or the Gulf of Mexico.

7. Development Process:

Support to Marine Recreation by Federal Programs.

- Land and Water Conservation Fund Act- Administered by the Secretary of Interior, Heritage Conservation and Recreation Service; authorizes grants to States on a 50-50 matching basis 1) to plan for outdoor recreation; 2) to acquire land for outdoor recreation; 3) to develop outdoor recreation facilities. Lands and facilities must be open to the general public and priority is given to projects for urban populations. Federal agencies may use a portion of the fund for acquiring land for national parks and seashores.

- National Park Service Act- Administered by the Secretary of Interior. The Secretary may establish seashore areas as national recreational areas in the National Park System if money is authorized by Congress in each instance. Ten national seashores have been designated by the Park Service.

- Coastal Zone Management Act of 1972- Administered by the Secretary of Commerce through the Office of Coastal Zone Management; requires State's coastal zone management plan to include a planning process for protection and access public beaches.

- Office of Sea Grant- An expanding variety of its research projects are concerned with some aspect of recreation.

Public Access vs. Private Ownership

In making coastal recreation available to all segments of the population, a basic issue is the rights of the private property owners which clashes directly with the public's interest to have free, unhindered access to the coast. The access-ownership issue is tied to State law and local custom. Most States recognize property rights for access to coastal beaches or for use of the beach. Also, most States allow local government to limit beach use to individuals based on property ownership or local residence. However, there are several legal theories which have been applied within several coastal States to entitle the public to use (now ownership) of beaches.

In order to distinguish public and private rights to beach use by statute, Oregon, Texas and the Virgin Islands have enacted "open beaches" laws. In California and Washington the public may have theoretic rights to beach use, but they are often not able to gain access across private dry sand beach.

Town beaches are under the control of a municipality; State and Federal facilities are open to the public but may be limited by lack of available parking.

A relatively small percentage of the U.S. total shoreline is in public owndership. Three legal approaches to provide additional coastal resources for public use are ownership, easement (the right to enter, use or pass across land owned by another), and tenancy. The Land and Water Conservation Fund Act of 1965 provides the bulk of Federal agencies. However, States have found it difficult to raise matching funds in numerous Federal programs requiring cost-sharing.

Private Sector Role

The private sector plays a major role in providing recreational opportunities for the public. Overall, private recreation land acreage in the U.S. exceeds public recreational lands. In addition, major industrial installations offshore provide recreational potential. The delineation is unclear between the government role and the role of private enterprise. A close coordination is needed between private and public enterprises to best serve the public. It has been suggested that commercial types of recreation where charges are made for facilities or services with the prospect of a profit should be left to private enterprise; while the government should provide the public with natural, historic, cultural and archeological sites.

Process

In general, the processes undertaken to achieve legal designation and protection of recreation/conservation marine sites might entail:

- Initial siting for further inquiry
- Specific scientific/biological/historical investigative inquiries.
- Proposals to specific jurisdictional bodies capable of assuring recognition and protection of the selected site.
- Assessments of the above investigative findings vs. functional needs.
- Assessments of needs vs. impinging/competing conflicts in uses of a selected site area.
- Key debates, conferences, and other avenues of discussion resolve issues stemming from any contradictory assessments determined above.
- A proclamation depending on the outcome of the above processes, refusing or granting a jurisdictionally preserved, protected, and/or conserved site.

MARINE RECREATIONAL STRUCTURES

MOTIVATING FACTORS	BARRIERS	OBVIATING FACORS
o Increasing demand for marine recreation of all types: sport fishing, diving, boating, swimming, sightseeing, tourism etc. o Increasing leisure time. o Increasing disposable income. o Enhance the quality of the recreational experience. o Alleviate over crowded shoreline facilities particularly in urban areas by developing alternative facilities including offshore. o Development of a local economy o Profit o To increase food supply o Multiple use of offshore structures enabling cost savings	o Costs incurred; profitability of private owned. o Negative environmental impacts. o Shortage and expensive cost of gasoline for traveling to the coast and in boats. o Regulatory requirements. o Conflicts of sea use/areas. o Access to the shore by the public; problem of private ownership of coastal areas. o Mishap resulting in loss of life or property	o Economic hardship reducing demand for recreation

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