1-8-1974

Deepwater Ports

Ronald Joel Calhoun
University of Rhode Island

This is an extremely good paper, although it is hardly what I would call a "short" one. I particularly like the way you tie up the port issue with the overall energy picture.

The University of Rhode Island
Kingston, Rhode Island

DEEPWATER PORTS

Marine Affairs Seminar

January 8, 1974

Ronald Joel Calhoun

This paper is written in partial fulfillment of requirements for the Master of Marine Affairs Program.

ACKNOWLEDGEMENTS

This paper is designed to provide an overview of the oil energy import problem and an analysis in a case study format of the various deepwater port alternatives for direct shipment and transshipment of foreign crude oil. This work was initiated prior to the recent expanded energy crisis and although touches on the problems of dependency of the United States to foreign crude oil, and the various alternative sources of energy, the essence of this paper is an analysis of the various deepwater port considerations for the direct or indirect importation of foreign crude oil; specifically along the Gulf Coast. The writer was extremely fortunate to encounter, in the course of the development of the analytical study of the Gulf Coast Deepwater Port problem, most cooperative and helpful people.

First, the writer received extensive technical and current information from Robert Bryan, an employee of the Department of Commerce. Second, the writer wishes to thank Dr. L. M. Alexander, Chairman of the Department of Marine Affairs, University of Rhode Island, and Dr. W.E. Turcotte, Emory S. Land Chair of Merchant Marine Affairs, Naval War College, for their assistance in obtaining information concerning deepwater ports, the energy crisis and other related maritime matters.

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Chapter I

Oil Energy Imports and Preliminary Analysis on Deepwater Port Alternatives

Introduction

The 18 April 1973 energy message submitted to Congress by President Nixon underscored the importance of deepwater port facilities as an important step in the resolution of the growing energy crisis. The president had this to say concerning deepwater ports:[1]

> It is clear that in the forseeable future, we will have to import oil in large quantities. We should do this as cheaply as we can with minimal damage to the environment. Unfortunately, our present capabilities are inadequate for these purposes. The answer to this problem lies in deepwater ports which can accommodate those larger ships, providing important economic advantages while reducing the risks of collision and grounding. Recent studies by the Council on Environmental Quality demonstrate that we can expect considerably less pollution if we use fewer but larger tankers and deepwater facilities, as opposed to the many small tankers and conventional facilities which we would otherwise need. If we do not enlarge our deepwater port capacity, it is clear that both American and foreign companies will expand oil transshipment terminals in the Bahamas and the Canadian Maritime Provinces. From these terminals oil will be brought to our conventional ports by growing numbers of small and medium size transshipment vessels, thereby increasing the risks of pollution from shipping operations and accidents. At the same time, the United States will lose the jobs and capital that those foreign facilities provide. Given these considerations, I believe, we must move forward with an ambitious program to create new deepwater ports for receiving petroleum imports. The development of ports has usually been a

> responsibility of State and local governments and the private sector. However, States cannot issue licenses beyond the three-mile limits. I am therefore proposing legislation to permit the Department of the Interior to issue such licenses. Licensing would be contingent upon full and proper evaluation of environmental impact, and would provide for strict navigation and safety, as well as proper land use requirements. The proposed legislation specifically provides for Federal cooperation with State and local authorities.

On 7 November 1973, President Nixon delivered another energy message in the wake of the October 1973 Yon Kippur Israeli-Arab War and the subsequent Arab economic retaliation for Israeli support in the form of a complete embargo of crude oil to the United States. The President had this to say about urgent pending Congressional legislation; of which deepwater ports was included:[2]

> Two years ago, in the first energy message any President has ever sent to Congress, I called attention to our urgent energy problem. Last April, this year, I reaffirmed to the Congress the magnitude of that problem and I called for action on seven major legislative initiatives. Again in June, I called for action. I have done so frequently since then. But thus far, not one major energy bill that I have asked for has been enacted....This is why it is time to act now on vital energy legislation that will effect our daily lives, not just this year, but for years to come.

During the same energy message, the President addressed a new megathought, the challenge of Project Independence:

> Finally, I have stressed repeatedly the necessity of increasing our energy research and development efforts. Last June, I announced a five year $10-billion program to develop better ways of using energy and to explore and develop new energy sources. Last month, I announced plans for an immediate acceleration of that program....Today the challenge is to regain the strength of self-sufficiency....Let us unite in committing the resources of this nation to a major new endeavor. An endeavor that in this bicentennial era we can appropriately call Project Independence....Let us pledge that by 1980 under Project Independence we shall be able to meet America's energy needs from America's own energy resources.

The President's criticism directed towards Congress in its failing to act on any of his proposals, including deepwater ports, followed by the challenge of Project Independence, was met with mixed emotions by energy experts. Those who are intimately involved with deepwater port economics contend that if the 1980 goal is feasible, then the United States does not need a deepwater oil terminal. From an industry point of view, the likelihood that near future commitment will be made in deepwater oil terminals will diminish until there is reasonable certainty that imports will be a big enough business to support the investment. Realistically, this self-sufficiency statement needs study and clarification. Collectively, many energy experts throughout the country labeled the plan unfeasible for 1980 or for many years thereafter.[3] Leaders on energy matters in Congress contend that year 1980 self-sufficiency will cost, (if at all possible), $20 billion over the next 10 years; double the recent commitment by the President.[4] The Senate, in full confirmation, in a 82 to 0 vote, on 7 December 1973, called for this broader research effort, a 10 year program and the spending of $20 billion.[5] Due primarily to increased executive pressure and the widening national energy crisis, the High Seas Oil Port Act (H.R. 5898) was approved by House committee on 5 December 1973 and sent on its way to the house floor.[6] The proposed legislation appropriately acquired a new name (from offshore ports and terminal facilities) which appears to be aimed at assuring single-purpose operations for oil offloading. This move, seemingly in line with the current energy crisis confusion, appeared to reject the feelings that a single-purpose offshore oil terminal had lost its economic justification in favor of a multi-purpose artificial island superport.

Project Independence is a demonstration of our efforts to create a trend towards self-sufficiency but the practice is ten to twenty years away. All the efforts cited by the President; namely the use of coal, exploitation of oil shale, offshore drilling, natural gas, expansion of nuclear power are transfused with problems both technological and environmental. Domestic coal reserves are enormous (nearly half the world's resources) and capable of providing the United States with sufficient heat and electricity for centuries, but the environmental restrictions and tremendous costs are prohibitive. To put the coal exploitation program on a crash basis and step up to the demand projection of 1.5 billion tons a year by 1985 would present growth costs of $15 billion or more.[7] Shale oil energy is a decade away for any substantial contribution to the energy crisis. The estimated 600 billion to 3 trillion barrel domestic shale oil reserves available are expected, even under maximum stepped up efforts, to produce only 250,000 barrels of shale oil a day by 1978.[8] By 1985, the shale oil industry could optimistically be expanded to provide 1 million barrels a day; roughly 6 percent of todays demand for oil and about 3 percent of the projected 1985 domestic demand of 30 million barrels.[9] Offshore drilling offers the most timely contribution but current reserves are measured conservatively in decades. The projection problem involves the quantification of production from offshore fields that as yet are undiscovered and again, are vastly expensive deep drilling tasks in deep waters on the continental shelves. If movement in lifting the current moratorium on drilling of wells in California offshore waters is successful, estimates of 200 to 300 million barrels of oil are forecast.[10] The North Slope oil reserves of Alaska are expected to deliver 2 million barrels by 1977.[11] Untapped and hard to recover resources in the Gulf of Mexico are estimated to hold reserves of 116 billion barrels.[12] Oil prospecting in these areas as well as off New England and the Middle Atlantic states has met with bitter resistance from environmentalists and economists who claim the cost could eventually run into hundreds of billions of dollars to exploit the undersea reserves.[13] Natural gas is by far the most desireable energy source environmentally but heretofore government regulations have kept the price to low competetively in an effort to bolster the demand for the cheaper oil. Although estimated to be substantially more costly than other more readily usable energy sources, the progress in technology is lacking for methods of extraction and conservative estimates are that if it is proved to be economical, the limited domestic supply is good for only a few decades at best.[14] The rapid increase in nuclear power as an energy source is based in the short run on the fission process which for various technological and safety standard reasons has had recent widespread plant shutdowns. Even with todays energy crisis dilemma, it is unclear when most of the nuclear power plants will ever become fully operational. Officials in the Atomic Energy Commission believe that by the 1980's, 150 nuclear power plants will be delivering 20 to 25 percent of the domestic electric power.[15] In any case, the basic nuclear fuel in use today, uranium, is in short supply and is also projected to be exhausted in a few decades. Breeder reactors are a strong substitute given needed technology breakthroughs. One drawback is the fuel, plutonium, considered as the most poisonous substance known to man, is an enviromentalist's nightmare.[16] Away in the future, probably beyond the year 2000, is the projection of fusion nuclear power with the unlimited availability of the necessary fuel, deuterium, the ultimate in energy production, is considered by most the farthest away from development.[17]

What do all these projections mean to the current energy crisis; and specifically in the next 10 to 20 years? The questions of rapid and timely technology breakthroughs coupled with the staggering costs is definitely something to consider. The National Petroleum Council estimates that an adequate fuel resouce program, including outlays for oil and gas exploration and production, necessary for self-sufficiency in the 1980's means spending upwards of $500 billion by 1985.[18] The reduction in consumption, unless extremely closely regulated is likely to be far from successful. Energy requirements are inevitably going to grow faster than the alternative domestic sources can possibley hope to take up the slack. The only answer in the next two decades, at the least, is to import substantial amounts of crude oil. Self-sufficiency simply cannot feasibly or rationally be attained by 1980 or most probably within this century. In contrast to this gloomy perspective the Arabs have recently reported to be willing to boost oil production more than double their pre-1973 Arab-Israeli War figure once political problems are solved; conservatively estimated, an end to the embargo would occur in 1974.[19] Self-sufficiency will be a reality in the twenty-first century. It is well on its way in theory; but practically speaking, the importation of foreign oil is essential in the 1980's as well as the 1990's to keep the pace with a growing America until the eventual goal of Project Independence is attained.

Analysis Overview

In approaching this analysis of foreign oil energy importation, consideration was taken of many port sites for United States crude oil delivery with sailings originating from numerous world points. The alternatives of foreign transshipment, dredged channels, United States deepwater transfer terminals and artificial island complexes were analyzed for transportation savings, costs for transfer, crude oil and product distribution to regional users within the South, Midwest and East Coast states. It was determined that the Gulf Coast was a highly feasible alternative for importation of foreign crude oil due to existing refinery and petrochemical industry, optimistic refinery expansion projections, the presence of a vast network of pipelines with expansion forecast and the existance of liberal environmental restrictions and land use regulations. In an effort to place reasonable limitations on the analysis the analyst will make the following assumptions:

1. All crude oil coming into the Gulf Coast will originate from the Middle East and Africa (see table 1 and figures 1 and 2). Because of lack of sufficient reserves and internal demands, Western countries will not be substantially supplying the United States with crude oil in the 1980's and thereafter.

2. A fleet mix of tankers between 110,000 and 500,000 dwt would be used as crude oil delivery vessels. The expected vessel sizes are to be between 226,000 and 279,000 dwt. Vessels in the 65,000 dwt range would be used in short delivery runs for crude oil and refined products.

3. The trend in construction of VLCC's will continue.

4. All ports of origin can now handle or will be able to handle up to 500,000 dwt tankers.

5. For a 250,000 dwt tanker, the maximum pumping rate is approximately 85,000 barrels per hour (unloading time about 21 hours at a berth or a buoy).[20]

6. Taking into consideration downtime both due to weather and maintenance, the deepwater port alternative designs are adequate to handle the required throughput.

Table 1

Projected Crude Oil Imports Gulf Coast

Year	Area of Origin	Percent of Total	Barrels per Calendar Day x 1000
1980	Middle East Africa	60 40	2,126 1,414
	Totals	100	3,540
2000	Middle East Africa	75 25	8,535 2,845
	Totals	100	11,380

Source: U.S. Department of the Army, Report of Gulf Coast Deepwater Port Facilities Texas, Louisiana, Mississippi, Alabama and Florida (Vicksburg, Mississippi: June 1973), p.48. (Hereafter referred to as Deepwater Port Facilities).

Supply and Demand

United States

The growth rate for the demand for petroleum products in the United States is estimated to be 4.4 percent to date continuing to year 1980 and 2.2 percent from year 1980 to year 2000.[21] Estimated demand production and import projections for crude oil and products in the United States in 1980 and 2000 are shown in table 2.

Gulf Coast

The Gulf Coast region refers to the littoral states from Florida to Texas. The Gulf Coast for some time has been a surplus producer of domestic crude oil and refined products. Currently, nearly half of the petroleum products

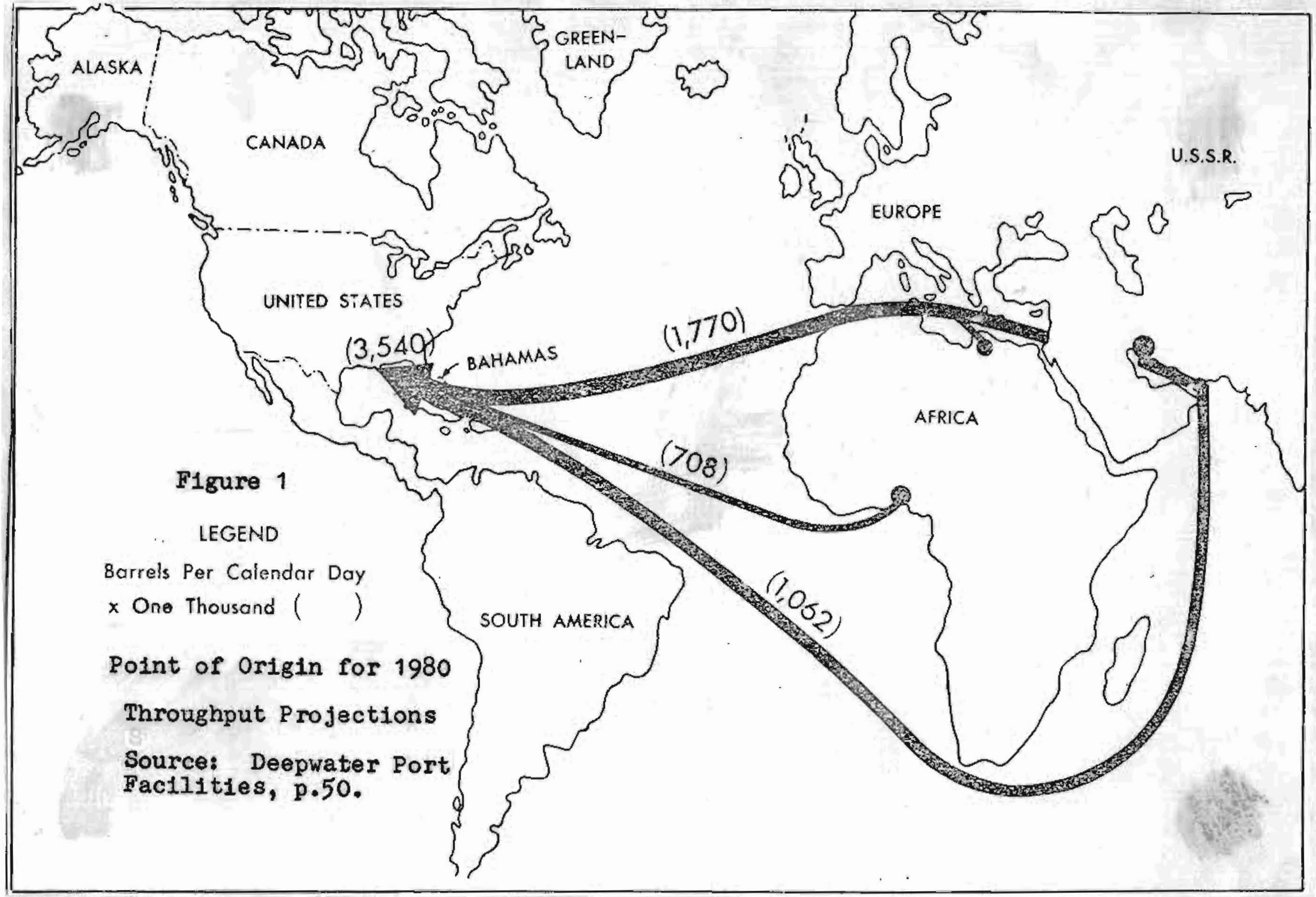


Figure 1

Point of Origin for 1980 Throughput Projections

Source: Deepwater Port Facilities, p.50.

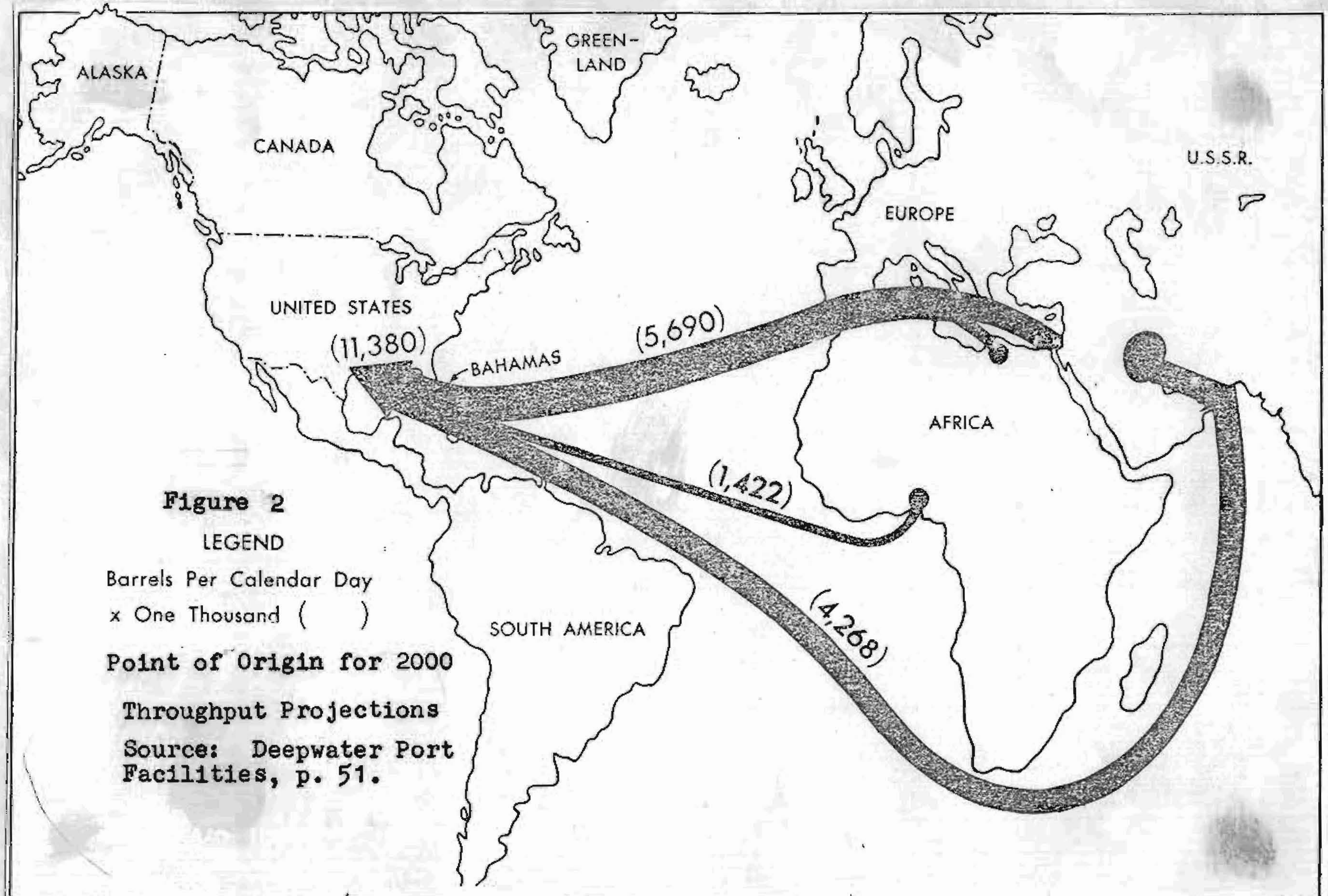


Figure 2

LEGEND

Barrels Per Calendar Day

x One Thousand ( )

Point of Origin for 2000

Throughput Projections

Source: Deepwater Port Facilities, p. 51.

Table 2

United States Demand/Supply Projections
Crude Oil and Products

(Barrels per Calendar Day x 1000)

	1980		2000	
	Crude Oil	Products	Crude Oil	Products
Demand	18,700	22,700	32,700	35,000
Production	11,800*	18,700	13,000*	32,700
Volume Imported	6,900	4,000	19,700	2,300

Source: Deepwater Port Facilities, p.48.
*Includes 2 million bcd from the North Slope of Alaska.

that are consumed on the East Coast come from Gulf Coast refineries.[22] Projected product shipment from the Gulf Coast to the East Coast and the Midwest is outlined in tables 3 and 4. This supply pattern has developed to a large extent because of the limited refinery construction along the Atlantic Coast which has been hampered both by strong enviromental restrictions and non-industrial land use policies. The Gulf Coast accounts for roughly 42 percent of the total United States refining capacity of approximately 13,000,000 barrels per calender day (bcd).[23]

If the Gulf Coast is to continue supplying crude oil and finished products to other regions and meet its own needs, foreign crude oil imports into the Gulf Coast region must increase from approximately 3,540,000 barrels per

Table 3

Petroleum Demand/Supply Projections
Gulf Coast

(Barrels per Calendar Day x 1000)

	1980		2000	
	Crude Oil	Products	Crude Oil	Products
Demand	9,510	4,680	15,880	6,980
Production	6,800	9,510	5,500	15,880
Surplus or (deficit)	(2,710)	4,830	(10,380)	8,900
Imports (Middle East/Africa)				
Gulf Coast	2,710		10,380	
*Midwest	830		1,000	
Total:	3,540		11,380	
Domestic Shipments				
Midwest		3,530		7,300
East Coast		1,300		1,600
Total:		4,830		8,900

Source: Deepwater Port Facilities, p. 58.
*Received in the Gulf Coast, shipped by pipeline to the Midwest.

calender day (bcd) in year 1980 to 11,380,000 bcd in year 2000 (see table 2). Accordingly, to meet the import demands, total Gulf Coast refining capacity is projected to increase from the present (1972) 4,818,000 bcd to approximately 9,062,000 bcd and 15,175,000 bcd in year 1980 and year 2000, respectively (see table 5 and figure 3).

Table 4

Projected Product Shipment From The Gulf Coast

(Barrels per Calendar Day x 1000)

Coastal Complex	1980		2000	
	Pipeline	Waterborne	Pipeline	Waterborne
Mobile	0	1	0	2
Baton Rouge	545	128	708	230
Pascagoula	134	36	178	65
New Orleans	364	105	444	190
Lake Charles	130	82	267	148
Beaumont-Port Arthur	571	393	1,125	709
Galveston-Houston Area	1,570	516	1,806	932
Corpus Christi	100	155	120	281
Subtotal:	3,414	1,416	4,648	2,557
Future East Coast Product Pipeline			1,695	
Total:	4,830		8,900	

Source: Deepwater Port Facilities, p.75.

Table 5

Gulf Coast Refinery Imported Allocation

(Barrels per Calendar Day x 1000)

Coastal Complex		Capacity	
	1972	1980	2000
Mobile	18	19	868
Pascagoula	270	519	1,557
Baton Rouge	585	1,334	1,847
New Orleans	548	872	1,270
Lake Charles	306	438	770
Beaumont-Port Arthur	1,291	1,915	3,333
Galveston-Houston Area	1,460	3,160	4,434
Corpus Christi	340	805	1,096
Total	4,818	9,062	15,175

Source: Deepwater Port Facilities, p. 79.

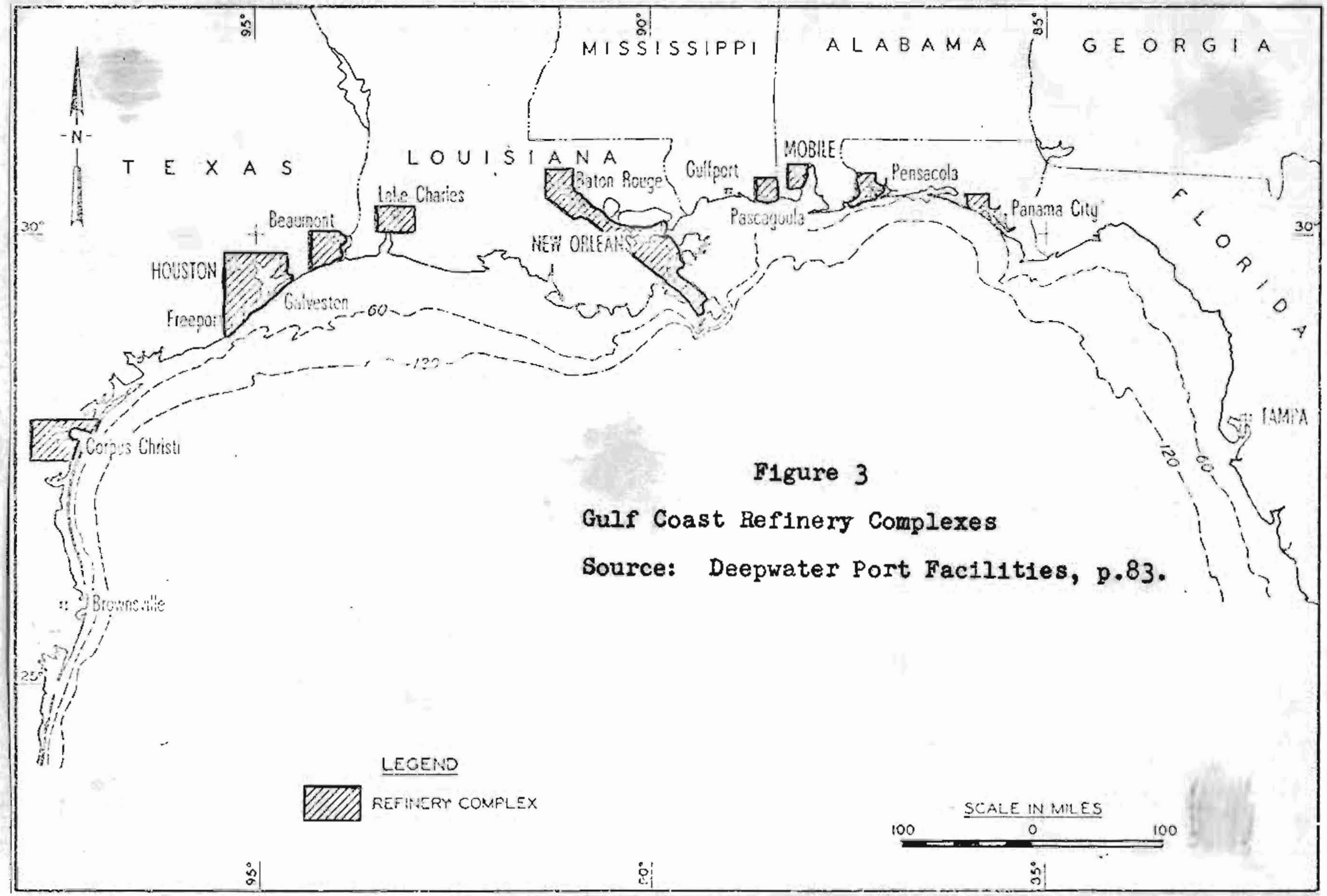


Figure 3

Gulf Coast Refinery Complexes

Source: Deepwater Port Facilities, p.83.

The growth in refining complexes is correlated to the projected waterborne small vessel shipments to the Northeast and to existing and planned growth of pipelines from the Gulf Coast to the Southeast, Northeast and the Midwest (see table 4). Withih these Gulf Coast refinery expansion and import allocation parameters, only minor shift in refinery location should occur between 1980 and 2000.

Vessel Economies of Size

Supertankers require port and channel depths of 70 to 100 feet. Generally speaking, the United States and typically the Gulf Coast completely lacks coastal ports of these depths. The Gulf Coast ports have channels and harbors averaging 36 to 46 feet in depth which can accomodate tankers of approximately 65,000 dwt. The obvious economics of size in using very large crude carriers of 250,000 to 500,000 dwt (VLCC's) is typified by the following projection. The United States is today dependent on foreign sources for approximately 30 percent of its crude oil supply. It is anticipated that by 1985, the dependence will be nearly 53 percent and the bulk will be originally sailed in VLCC's from the Mediterranean or the Persian Gulf.[24] When VLCC's are used, these long haul shipping costs are reduced by as much as 50 percent when compared with tankers of 65,000 dwt.[25] In 1971, the average size ship carrying imported crude oil to the United States was 29,000 dwt and accounted for 4,000 of the 67,770 actual tanker traffic port calls.

If no increase in port facilities with respect to accomodating deep draft vessels takes place, crude oil imports would result in about 14,600 arrivals per year by 1980, a 265 percent increase.[26] It is doubtful that enough of these small tankers would be available, but if they were, the attendant cost and shipping congestion within the already crowded harbors and channels of the United States ports would be staggering.

Deepwater Port Alternatives[27]

Bahamas Transshipment Terminal

There are two obvious alternatives to the provision of deepwater terminals in the Gulf of Mexico. Small vessels, in the present 40,000 to 65,000 dwt size range, may continue to transport crude oil direct to the Gulf using existing navigation channels; or very large crude carriers (VLCC's) may transport the oil to a deepwater port in the Bahamas where it would be transferred to smaller vessels and brought to the Gulf. Preliminary estimates of the total transportation cost by small vessels direct to the Gulf indicated that this alternative would cost about twice as much as transport by VLCC's to the Bahamas and then by smaller vessels to the Gulf. The latter alternative is the most likely if deepwater facilities in the Gulf are not provided and was used as the base case for this study. The equivalent annual cost for the base case was calculated and used to compute the net transportation savings for the other alternatives investigated (see table 6).

Table 6

Bahamas Transshipment Terminal Alternative Costs

(X $ million)

	1980	2000
Average annual cost of ocean leg Throughput: 1980-3,540,000 2000-11,380,000	561	1,913
Average annual cost of transshipment	228	711
Facility present worth first costs Includes: U.S. unloading cost, storage requirements, crude oil distribution, pipelines to refineries, product pipelines to Midwest and East Coast.	1,155	
Annual Operations and Maintenance Costs	29	

Source: Deepwater Port Facilities, p. 110.

Dredged Channels

A system composed of five dredged channels was investigated for enlargement to 1,000 feet in width at a depth of 100 feet. Theses five channels were considered as a system, and no individual channel optimization was considered. Each of the five channels in the system consists of an approach channel 1,000 feet wide at the depths stated above, an inland turning basin with berthing facilities, a tank farm adjacent to the turning basin for 7-day throughput storage and pipeline distribution to the respective refining complexes. The channels and projected throughput (x 1000 bcd) for years 1980 and 2000 included in this system are as follows (see figure 4 and table 7):

Mobile Harbor (1980 - 245, 2000 - 2,208)

Mississippi River, Southwest Pass to Baton Rouge (1980 - 1,538, 2000 - 3,035)

Sabine Pass (1980 - 569, 2000 - 2,566)

Galveston Harbor (1980 - 765, 2000 - 2,773)

Corpus Christi (1980 - 423, 2000 - 798)

Table 7

Summary of Costs For 100-Foot Depth Dredged Channel Alternative

Item	First Cost (x $1000)
Mobile Harbor	1,049,067
Mississippi River	3,489,740
Sabine Pass	1,904,623
Galveston Harbor	1,856,523
Corpus Christi	484,462
Crude oil distribution network	176,324
Products distribution network	646,403
Total:	9,607,142

Throughput: 1980 - 3,540,000
2000 -11,380,000

Total Transportation Costs: (x $ million)	1980	2000
	615.1	2217.9

Source: Deepwater Port Facilities, Appendix E, p. 16.

Artificial Islands

Three site locations were analyzed, each offshore in approximately 100 feet of water, were considered for the location of artificial islands to offload and store crude oil from VLCC's. Each artificial island was sized for 10-day throughput storage and was protected by a breakwater which formed the outer wall of the island. An interior turning basin, exposed only at the entrance, was provided

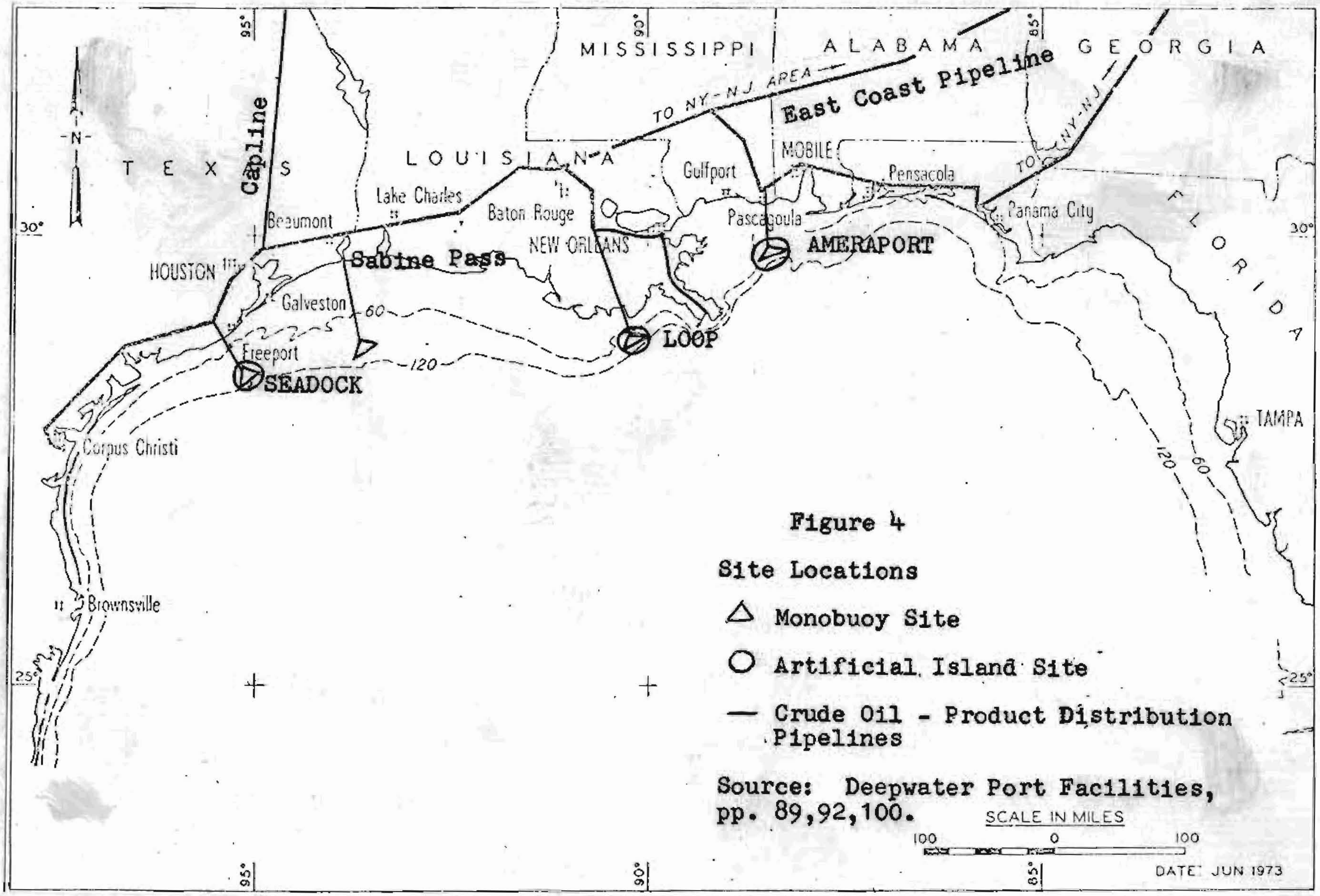


Figure 4

Site Locations

Source: Deepwater Port Facilities, pp. 89,92,100.

for berthing and offloading operations. The site locations considered in this system are as follows:

The Mobile-Pascagoula site is located southwest of Mobile approximately 32 miles offshore.

The Bayou La Fourche site is located south of New Orleans approximately 17 miles offshore.

The Freeport site is located southeast of Freeport approximately 30 miles offshore.

Monobuoy Systems

Four site locations were analyzed; each offshore in approximately 100 feet of water were considered for the location of monobuoys to offload VLCC's. At each of the monobuoy sites, from one to six monobuoys were clustered around a central platform; the number being dependent upon the throughput volume. The monobuoys, anchored to the sea bed through a pile base, would be approximately 5,000 feet apart to allow the VLCC's to weathervane about the buoys. Cargo transfer takes place from the VLCC to the buoy through a floating hose connected to the ship's manifold and to a fluid swivel on the buoy. The buoy, swivel, and hose connection are free to rotate with the ship. Each monobuoy is connected to the central platform by a 48-inch pipeline. The central platform contains one pump unit for each line to onshore plus one spare, a central control room, personnel quarters, a navigation control system, a heliport, and emergency and safety equipment. One 48-inch pipeline per buoy was provided from the central platform to the onshore tank farm. The site locations considered in this system are as follows:

The Mobile - Pascagoula site is located southwest of Mobile approximately 32 miles offshore.

The Bayou La Fourche site is located south of New Orleans approximately 17 miles offshore.

The Sabine Pass site is located south of the Louisiana, Texas border approximately 80 miles offshore.

The Freeport site is located southeast of Freeport approximately 30 miles offshore.

Optimum Alternatives

Both the monobuoy and the artificial island alternative have numerous variations in sitings, grouped complexes, distance from shore to the 100 foot depth contour, refinery location, and crude oil and product distribution networks. Of the 20 alternatives, one monobuoy alternative of three separate ports (see table 8) and one artificial island alternative of two separate islands (see table 9) are singled out as the most economically and environmentally feasible (see figure 4).

Financial Analysis

Costs for the various alternatives are expressed as the present worth of all first costs, the equivalent annual first cost and the equivalent annual maintenance and operations cost. All disbursements are assumed to be discounted from the base date of 1979; using 1973 capital costs. The alternatives were all sized for the ultimate, or year 2000

Table 8

Summary of Costs For Optimum Monobuoy Alternative

(X $ million)

Item	First Cost	Annual O & M Cost
Mobile-Pascagoula (3 buoy)		
Monobuoy construction	213.4	6.7
Throughput: 1980-245,000 2000-2,208,000		
Crude oil inland distribution	12.3	0.3
Bayou La Fourche (4 buoy)		
Construction	249.7	7.8
Throughput: 1980-1,538,000 2000-3,035,000		
Crude oil inland distribution	142.7	3.9
Freeport construction (5 buoy)	512.4	14.8
Throughput: 1980-1,757,000 2000-6,137,000		
Crude oil distribution (inland)	282.9	7.9
Product distribution (cross country)	647.7	23.6
Total Transportation Costs:	1980	2000
(X $ million)	671.4	2272.8

Source: Deepwater Port Facilities, Appendix E, Attachment E-1, pp. 1-26.

throughput; although, berths, buoys and storage facilities were added as the demand required. Because of the complication of varying economic lifetimes of the major system components and the incremental additions of buoys and marginal berths to the terminal alternatives, all costs were converted to a present worth first cast and then discounted to equivalent annual first costs at 8 percent over

Table 9

Summary of Costs For Artificial Island Alternative

(X $ million)

Item	First Cost	Annual O & M Cost
Mobile-Pascagoula Island construction (5 berths) Throughput (x million bcd): 1980-1783 2000-5243	1,407.6	34.5
Freeport Island construction (5 berths) Throughput (x million bcd): 1980-1757 2000-6137	1,516.5	37.2
Crude oil inland distribution	789.0	30.6
Product cross country distribution	646.4	23.3

	1980	2000
Total Transportation costs: (X $ million)	669.4	2268

Source: Deepwater Port Facilities, p. 18.

an average economic life of 25 years. This method automatically accounted for replacement costs of more perishable components. Equivalent annual maintenance and operations costs were derived from present worth costs and expressed as equivalent annual costs over the economic lifetime of the alternatives. (The capital recovery factor for 8 percent over 25 years is .09368.)

Weather Maintenance and Holiday Downtime

Single-point mooring (SPM) buoys are unprotected by barriers but are considered highly suited for operations at offshore locations where sea and weather conditions may be severe. A VLCC can remain moored at a monobuoy in over 15-foot significant seas in combination with 60 knot winds and strong currents. Berthing operations would be precluded in 6 - 8 foot seas with 25 knots of wind, and crude oil transferring in 10 - 12 foot seas with 40 knots of wind.[28]

On an annual basis, in the Gulf, waves up to 8 feet can be expected for a total of 20 days per year, up to 12 feet for about 4½ days per year and up to 20 feet for about one-half day per year.[29] An artificial island sheltered harbor would have lower berth high seas downtime with the same weather conditions (estimated to be in the area of about 50 percent less), but would not reduce downtime due to wind or fog.[30]

For the purposes of this study, downtime to weather will not appreciably prevent the demand throughput requirements. Carrier waiting time during periods of high seas is unavoidable.

The available working days for a monobuoy (one buoy) would be 334 taking into consideration maintenance and local and federal holidays; for the artificial island berth, 350 days.[31]

Inland and Deepwater Port Distribution Systems

The secondary distribution tug/barge was costed with each offshore alternative and was found to be significantly more expensive than underwater pipeline distribution and will not be considered further.[32] Three product pipelines, Colonial, Plantation and Dixie, move petroleum product shipments to the Atlantic Coast area. The pipelines will be expanded to provide for projected increased product shipments to include a major new East Coast product pipeline. Shipment of both crude and petroleum products to the Midwest region will be moved through the expanded Capline system. In addition, waterborne shipment of products by shallow draft tankers will supplement the product pipelines to the Atlantic Coast. Crude oil distribution networks between the deepwater port complexes and regional refinery complexes by pipeline were considered in the costing of the various deepwater alternatives.

Gulf Coast Deepwater Port Development[33]

Most of the activity along the Gulf Coast is being accomplished in Louisiana, Texas, Alabama and Mississippi. In Louisiana, 13 oil companies have formed a consortium known as LOOP (Louisiana Offshore Oil Port, Inc.). They have planned a facility to tie into the Capline pipeline. LOOP would like to start construction in 1974 and have the facilities in operation by late 1976. In Texas, 12 oil companies have formed a similar consortium called SEADOCK. This group also plans on a construction start in 1974 with completion in 1976. Alabama and Mississippi have also formed a Joint Superport Task Force called the Ameraport Council, and are proceeding with the studies aimed at justifying a deepwater port facility off the Alabama/Mississippi Coast.

Environmental/Ecological Analysis of Alternatives

The public's view seems to be concentrated on the potential environmental and ecological damage that might result from petroleum spills. The danger of uncontrolled release of petroleum into the environment arises primarily from the possibility of accidental collisions and groundings of vessels, from spills during transfer of petroleum from ocean going vessels to either other tank vessels, or into pipelines and storage tanks, and from the possibility of leakage of the tanks themselves. The degree of hazard is partly a function of the delivery system employed, including the size, design, and operation relating to the transfer and storage of petroleum. The probability of spills tends to increase with the greater congestion of waterways associated with the use of smaller vessels. In general, primary ecological and environmental problems associated with the various deepwater ports are as follows:

Bahama Transshipment Terminal. If deepwater terminals in the Gulf of Mexico are not developed, either a larger number of small vessels will continue to transport crude oil using existing navigation channels, or VLCC's will transport crude oil to a deepwater port in the Bahamas where it would be transferred to smaller vessels for shipment to the Gulf. Under either of these conditions, the probability of an oil spill occurring at existing ports is greater than with offshore facilities; due primarily to increased vessel traffic in channels and harbors. In addition, crude oil is more likely to be introduced directly into the estuarine and marsh environment with the transshipment alternative than with offshore facilities.

Dredged Channels. The system of five dredged channels considered in this study would have the greatest environmental impact of facility alternatives considered. Construction and maintenance of these channels would require considerable disruption of aquatic and terrestrial habitats due to dredging activities and disposal of dredged material. Associated areas of environmental disruption include interference with ground-water quantity and quality, salt-water intrusion, and turbidity. Also, probabilities that crude oil could be spilled directly in estuaries and marshes would be greater with this alternative than with offshore facilities.

Artificial Islands. The primary impacts of artificial islands would be related to possible alteration of existing current patterns and loss of bottom habitat at the site and at the piping area. The effects of these islands on currents and water circulation are not known, and would vary from site to site. The structures themselves would create some additional habitat for marine organisms. This alternative provides the greatest opportunity to provide for the containment of oil spills occurring during offloading. Impacts of a more temporary nature include increased turbidity during construction and disruption of bottom and marsh habitat for pipeline installation.

Monobuoy Systems. Monobuoys themselves would have little impact on the environment. Primary impacts would result from casualty oil spills, spills during offloading and pipeline operation. Dredging requirements to construct the monobuoy would be minimal except for dredging necessary to construct a pipeline for transporting oil to shore. Therefore, dredging impacts will be short-term and transitory.

National Overview

The deepwater port problem impacts on broader, higher-level objectives of the national security and the national ecomomy. An industrial nation like the United States is dependent upon continued growth, both internal and external. This growth has placed the United States in a position of world industrial, economic and political power. Transportation restriction specifically in the area of the deprivation of a competitively priced crude oil energy source will have widespread ramifications. In the area of national security, domestic oil reserves must be protected for possible use in the event of war or economic blackmail from the oil producing nations. To preserve the domestic reserves, the importation of oil, until the United States achieves substantial domestic self-sufficiency, is mandatory.

Another form of self-sufficiency involves the refining industry. In this regard, without a superport, the refining industry would relocate to foreign shores (transshipment terminals), and their products would be imported with the attendant loss of American jobs and an overall degredation of our regional and national economy. Such capital movements would also be reflected in an added unfavorable balance of payments with resulting damage to the value of the dollar.

The United States industrial base is dependent upon a low cost sea transport of liquid and bulk raw materials. The development of superports is mandatory to keep abreast of world shipping and the economies of scale for OBO (oil-bulk-ore) super carriers. Large industrial complexes will lose their cost-effectiveness if low cost waterborne transportation to both recieve and ship vital raw materials is not achieved. Coupled with environmental concern, absense of inexpensive water transportation could well desolate large areas of industrial concentration.

Other consequences of the lack of deepwater port development include the following:

1. Failure to maximize the benefits of constructing large U.S. flag vessels.

2. Promotion of industrial isolationism in that many foreign markets would simply be unattractive to the U.S. businessman.

3. Reduction in the U.S. prestige and "presence" abroad.

International Jurisdictional Problems [34]

A questionable area is our right to the use of the seabed along the continental shelf outside our territorial zone (3 miles); when the recovery of natural resources is <u>not</u> the purpose (ie., as opposed to offshore drilling operations). The President has recently proposed legislation amending the Outer Continental Shelf Lands Act (OCSLA) to provide for a so called "right-of-way" for pipelines and the establishment of a "navigation" hazard in the form of a buoy terminal complex or an artificial island. The legislation is intended to provide a complete legal regime for liscensing of the waters and the seabed beyond the 3 mile limit. According to the Geneva Conventions of 1958, within the limit of the territorial sea the jurisdiction of the coastal state is virtually absolute; subject only to allowing rights to foreign vessels of innocent passage and entry in distress. If the deep draft port facility must utilize the high seas or the seabed beyond the seaward limit of the territorial sea, the legal regime is vague and without precedent. An equally weak justification considered sufficient by many law makers is the other uses criteria "recognized by the general principles of international law." All the open sea deepwater ports considered in this study are on the high seas. A deepwater port may or may not be internationally permitted use of the high seas as prescribed by the Law of the Sea. This being the case, the process of emerging norms of customary international law provides at least a mechanism for undertaking the construction of such facilities pending agreement on the subject.

Summary

The President strongly emphasized deepwater port development in his mid-April energy message prior to proclaiming a national goal six months later of self-sufficiency by 1980 through the challenge of Project Independence. One of the major legislative proposals still outstanding yet continuing to be emphasized by the President and Congress is deepwater ports development. The sudden emergence of Project Independence subsequent to the Arab oil embargo has increased the risk of capital investment but realistically the national need of deepwater ports still remains. The question is the assumed availability of large amounts of imported oil. Project Independence is seen by many energy experts as unfeasible in the 1980's and possible the 1990's due to gaps in technology and spiraling prohibitive costs.

The analysis of the alternatives for deepwater development include foreign terminal transshipment, the use of Gulf Coast dredged channels, offshore monobuoy and artificial island complexes. The economic analysis considers crude oil originating in the Persian Gulf and Africa with supertankers carriers as the driving force toward beneficial savings in transportation cost. Advocate views self-sufficiency and ecology are briefly addressed although not in discrete quantitative terms. The necessary facility costs are available to base a cost-effectiveness comparison on year 1980 and 2000 data. Capital investment is discounted at 8 percent over an economic lifetime of 25 years with alternatives sized for an ultimate year 2000 throughput.

Chapter II

Case Study Analysis for Gulf Coast Deepwater Ports

Goal and Objective

1. This study is a regional investigation of the deepwater port potential of the United States littoral to the Gulf of Mexico. The goal is to provide adequate crude oil throughput to the Gulf Coast refineries for regional domestic requirements and external demands of petroleum products to the Atlantic states and both crude oil and petroleum products to the Midwestern states. Historically, the Gulf Coast has been a surplus producer of both crude oil and products; receiving almost all its crude oil from local fields both on the mainland and the continental shelf. Current projections indicate that the production of crude oil along the Gulf Coast will peak and decline in the near future. By year 1980, projected demands placed on Gulf Coast refineries and crude oil shipment will create a deficit of 3,540,000 bcd; growing to 11,380,000 bcd in year 2000. Therefore, the importation of crude oil will be necessary to both supplement regional needs and external demands. The coastal refinery capacity is projected to increase linearily from the present 4,818,000 bcd to approximately 9,062,000 bcd and 15,175,000 bcd in years 1980 and 2000, respectively.

2. The objective is to identify the advantages (benefits) and disadvantages (costs) of using supertankers from the Middle East and Africa to determine the most economically and environmentally feasible deepwater port system for future development.

Measures of Effectiveness and Cost

1. A measure of effectiveness is the throughput of foreign crude oil for a given refinery complex demands. For this study, this evaluation of effectiveness for the various deepwater alternatives is fixed. The projected expanded refinery capacities and subsequent imported oil allocations drive the effectiveness to assume inflexible fixed demands. A more formidable measurement of effectiveness (MOE) is the net annual transportation savings. The net annual transportation savings is the difference between the total annual costs of the Bahamas transshipment (base case) alternative and the other individually considered alternatives.

The measurement of cost (MOC) is the total annual costs of the alternative including all transportation, facility, and crude oil and product distribution networks. The end point for this analysis is considered to be at the product distribution points of the Midwest, East Coast and the Gulf Coast regions.

Criterion

1. The test of preferredness to be used in evaluating the alternatives will be based on maximizing annual

net transportation savings (MOE) at fixed crude oil import demands. Due to the spread of refinery complexes on the Gulf Coast, a mix of deepwater ports was included within both the island and monobuoy alternatives. Each component of the preferred alternative will be separately analyzed by a marginal cost-marginal effectiveness criteria. While one alternative may best meet the initial criterion, a component port within the alternative will be analyzed, according to its individual cost-effectiveness. Additionally, indirect effects of the environment will be considered.

Assumptions-Constraints

1. The financial data provided in each case consists of the total present worth of all first costs, the equivalent annual facility first cost (including replacements), the equivalent annual maintenance and operations costs, the annual net transportation savings and the net savings per unit of throughput expressed per barrel. All disbursements are discounted from the base date 1979. The present worth costing provides for incrementally implementing component stages as demanded by increasing throughput requirements. Throughput growth and refinery expansion is assumed to increase linearly from year 1980 to year 2000.

2. Maximum throughput volume according to refinery allocation demands was assumed throughout the analysis.

3. Because of expected internal demands, supertanker economies of scale, and limited reserves of Western

oil producing countries, the Middle East and Africa will be the only countries importing crude oil to the Gulf Coast deepwater ports.

4. The upward trend in construction of very large crude carriers (VLCC's) will continue. The largest tanker in service today is the Globtik Tokyo, 475,000 dwt, with a draft of 92 feet fully loaded.[35] No tankers less than 110,000 dwt would deliver crude oil to a Gulf Coast deepwater port. Tankers in the ranges of 65,000 dwt would be utilized in short leg delivery runs for crude oil and refined products. The service of tankers ranging in size between 110,000 and 500,000 dwt; with the mean vessel sizes (the "most probable ship") between 226,000 and 279,000 dwt will be assumed.

5. The demand for petroleum products in the United States will increase rapidly in the near future at a growth rate of approximately 4.4 percent annually from 1973 to 1980 and 2.2 percent annually from 1980 to 2000. It is likewise assumed that domestic crude oil production is expected to increase only slightly (decrease slightly for Gulf Coast production); therefore, necessitating crude oil importation. Accordingly, refinery capacity on the Gulf Coast is expected to meet projected external as well as internal demands (see table 3).

6. Each alternative was analyzed with secondary modes of transportation (offshore terminal to intermediate storage) of tug/barge and pipeline. The tug/barge distri-

bution was not considered competitive and will not be considered in the analysis.

7. An overall economic life time of 25 years was used with present value fixed costs discounted at 8 percent.

8. If deepwater facilities are not provided in the Gulf, the possible alternative of transporting crude oil to Gulf Coast terminals directly from the Middle East and Africa in small tankers was assumed highly uneconomical. It is estimated that it would cost approximately twice as much as transshipping oil in VLCC's from the Bahamas base case; therefore, it will not be considered in the analysis.

Alternatives
(see tables 10, 11 and 12)

<u>Alternative A - Bahamas Transshipment (base case)</u>

1. Ostensibly a no action alternative in which VLCC's would transport crude oil to a deepwater port in the Bahamas and transfer the crude oil to smaller vessels for transshipment to the Gulf Coast.

<u>Alternative B - Dredged Channels</u>

1. A system of five dredged channels that would supply the crude oil directly to the major refinery complexes; thus, not necessitating an offshore deepwater port facility.

<u>Alternative C - Artificial Islands</u>

1. A two site alternative, both islands offshore in approximately 100 feet of water, was considered optimum from an array of proposed sites.

<u>Alternative D - Monobuoy Systems</u>

1. A three site alternative, each site offshore in

approximately 100 feet of water, was considered optimum from an array of proposed sites.

Comparison of Alternatives

As shown in table 10, alternative B, the dredged channel system, was not economically feasible in any respects when compared to alternative A, the base case. Alternative C, the artificial island, was not economically feasible; although marginally when projected to year 2000 throughput (estimated to be a deficit savings of 1¢ per barrel). The monobuoy alternative was economically feasible for all practical purposes throughout the test period. A deficit annual transportation savings of $2.9 million annually was realized at the outset during year 1980, but it is not a realistic measure of effectiveness. The present worth first cost concept of annually costing the alternatives with an equivalent cost is biased in that the initial cash outlays are greater than they would otherwise be. The deficit is substantially small when compared to the next best alternative (the monobuoy annual savings deficit is approximately 1 percent of the island deficit).

Further quantitative analysis for the preferred monobuoy alternative can be illustrated with the selection criterion of marginal cost-marginal effectiveness. This method of analysis is particularly meaningful in that it allows a cost-effective measure of each port complex within the given alternative. In figure 5, a smooth curve is drawn through the three plotted sub-systems; each normalized

Table 10

Summary of Alternatives

(X $ million)

Alternatives (Location)	Annual Throughput (x1000 bcd) 1980	Annual Throughput (x1000 bcd) 2000	Annual Transportation Cost 1980	Annual Transportation Cost 2000	Facility First Cost	Annual O & M Costs
A Bahamas Trans-Shipment To:			789.4	2624.4	1155.0	29.0
Panama City	0	424				
Pensacola	0	424				
Mobile Harbor	5	440				
Pascagoula	240	920				
Mississippi River	1538	3035				
Sabine Pass	569	2566				
Galveston Harbor	765	2773				
Corpus Christi	423	798				
Total:	3,540	11,380				
B Dredged Channel			615.1	2217.9	9607.1	666.1
Mobile Harbor	245	2208				
Mississippi River	1538	3035				
Sabine Pass	569	2566				
Galveston Harbor	765	2773				
Corpus Christi	423	798				
Total:	3,540	11,380				
C Artificial Island			669.4	2226.8	4359.5	125.6
Mobile-Pascagoula	1783	5243				
Freeport	1757	6137				
Total:	3,540	11,380				
D Monobuoy			671.4	2272.8	2061,1	65.0
Mobile-Pascagoula	245	2208				
Bayou La Fourche	1538	3035				
Freeport	1757	6137				
Total:	3,540	11,380				

Table 11

Summary of Alternatives

(x $ million)

Alternatives	Facility First Cost	Annual Total Cost (MOC)		Annual Net Transportation Savings MOE		$ Per Barrel	
		1980	2000	1980	2000	*1980	**2000
A	108.2	926.6	2761.6	----	----	----	----
B	900.0	2181.2	3784.0	-1254.6	-1022.4	-.97	-.246
C	408.4	1203.4	2802.8	- 276.8	- 41.2	-.214	-.01
D	193.1	929.5	2530.9	- 2.9	+ 230.7	-.0022	+.056

*Based on 1.2921 x 10^9 barrels per year throughput.
**Based on 4.1537 x 10^9 barrels per year throughput.

Table 12

*Ranking By Transportation Savings

Rank	Alternative	**Net Savings (x $ million)	
		1980	2000
1	Monobuoy	- 2.9	+ 230.7
2	Artificial Island	- 276.8	- 41.2
3	Dredged Channel	-1254.6	-1022.4

*Discounted at 8 percent over 25 years economic life.
**Bahamas transshipment alternative was used as the base case.

to the most costly and the most effective (greatest throughput) port component. These normalized cost and effective comparators are illustrated in table 13. The tangent line having a slope of 45 degrees ("isomarginal cost-effectiveness" line) is tangent and closest to the curve at the La Fourche site for both the 1980 and 2000 throughput projections.

Table 13

<u>Marginal Cost-Marginal Effectiveness Criterion</u>

Monobuoy Alternative

Port	*Facility Annual Cost	Facility Annual Throughput		**Relative Annual Cost	**Relative Annual Throughput	
		1980	2000		1980	2000
Freeport	97.20	1757	6137	1.0	1.0	1.0
Bayou La Fourche	48.46	1538	3035	.50	.88	.50
Mobile-Pascagoula	28.14	245	2208	.29	.14	.36

*Facility annual cost included the construction cost, O & M and the crude oil network distribution costs. The product distribution network was not included.

**The costs and throughputs are normalized in the mathematical sense and thus expressed as the relative cost and throughput as a percentage of unity. The comparator for both cost and effectiveness is the Freeport monobuoy complex.

Sensitivity

<u>Discount Rate</u>

1. The initial discount rate used to determine the preferred alternative was 8 percent; a rate too low and

Figure 5a

Marginal Cost-Marginal Effectiveness*

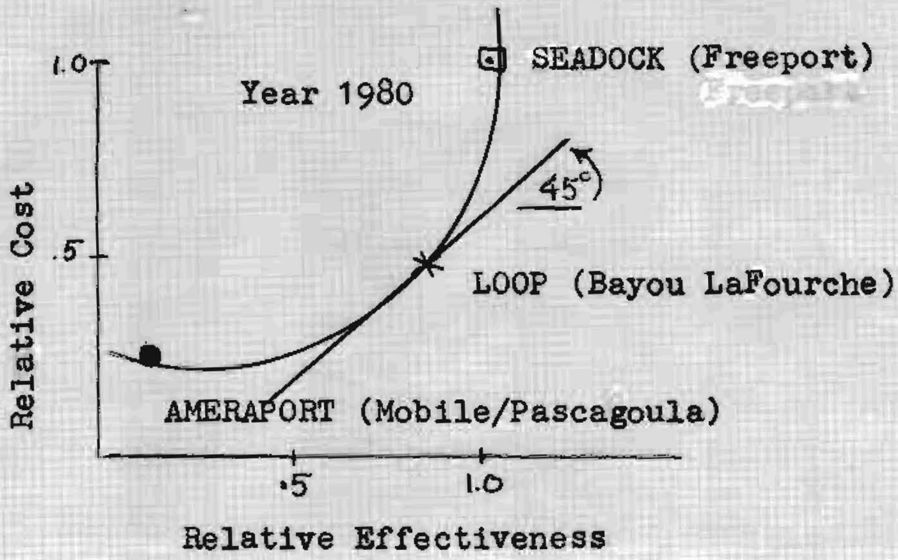
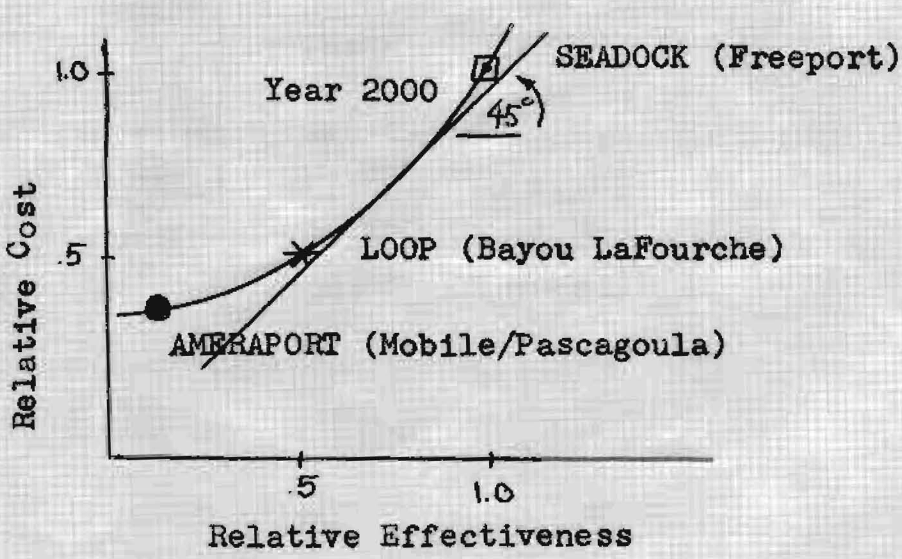


Figure 5b

Marginal Cost-Marginal Effectiveness*



*Comparison of cost (C) and effectiveness (E) where the relationship C=f(E) exists. The proper selection of the alternative closest to the tangency to the isoeffectiveness curve illustrates the principal of marginal cost-marginal effectiveness (utility). The critical point (of the selection criterian) is that point at which an increment of cost is matched by an equal increment of effectiveness; mathematically where dC/dE = 1 (an angle of 45 degrees with each axis).

generally unacceptable to industry given the substantial risks involved in constructing a deepwater port. One of the obvious risks is the possibility of a major forced change in United States oil import policies created by external diplomatic confrontations with the Organization of Arab Petroleum Exporting Countries (OAPEC). This would drastically reduce the necessity of a deepwater port for large scale VLCC transfer with the attendant economics of scale as projected in this study. There may be changes in policies affecting other energy sources; such as nuclear power, through breakthroughs in technology, which will greatly decrease demand for crude oil. In each case the risks are also accounted for through the useful or economic lifetime concept vice the physical lifetime of a deepwater port facility. The economic lifetime of 25 years assumed in this study is approximately one-half of the proposed physical lifetimes of the major components of the port, the buoys and platforms.[36] Nevertheless, the discount rate of 8 percent is considered too low. The Office of Management and Budget (OMB) has set a 10 percent standard discount rate for comparable government investments with similarly unpredictable varying discount rates. High risk investments are generally in the 10 to 15 percent range. For this study, the preferred alternative was analyzed for discount rates of 10, 15 and 20 percent (see table 14 and figures 6 and 7). As each total capital investment is discounted, the measure of effectiveness remains the annual net transportation savings as compared

Table 14

Discount Rate Sensitivity Monobuoy Alternative

(x $ million)

Discount Rate	% Change In Discount Rate	Net Total Cost (MOC)		**Net Transportation Savings (MOE)		% Change MOE	
		1980	2000	1980	2000	1980	2000
8%	-------	929.5	2530.9	- 2.9	230.7	----	----
10%	+25%	963.5	2564.9	- 17.9	215.7	- 71.7%	- 6.5%
15%	+87.5%	1055.3	2655.9	- 58.4	176.2	-211.0%	-23.6%
20%	+150%	1153.0	2754.4	-101.2	132.4	-358.0%	-42.6%

*Capital recovery factor (CRF) = $\frac{i\,(1+i)^n}{(1+i)^n-1}$ where, i = interest rate (discount rate) and n = years to recover investment. Data: n = 25 years; CRF = .09368 for 8%, .11017 for 10%, .15470 for 15% and .20212 for 20%.

**For 8, 10, 15 and 20 percent discount rates, the average net annual transportation savings based on 7,460,000 bcd throughput (during year 1990) is $113.9 (4.2¢/barrel), $98.9 (3.6¢/barrel), $58.9 (2.2¢/barrel) and $15.6 million (0.6¢/barrel), respectively.

with the base case Bahamas transshipment terminal. Although implicitly, a profit motive is always apparent, the objective of this study is to meet demand throughput at minimum transportation cost (or, in the same sense, at maximum net transportation savings). All the alternatives, with the exception of the monobuoy system, are not economically feasible at the 8 percent discount rate.

The preferred alternative, the monobuoy system experienced a net transportation savings deficit during the outset of the test period years 1980 to 2000. Marginally uneconomical as compared to the base case, the net loss is

Figure 6

<u>Sensitivity Analysis</u>

Discount Rate

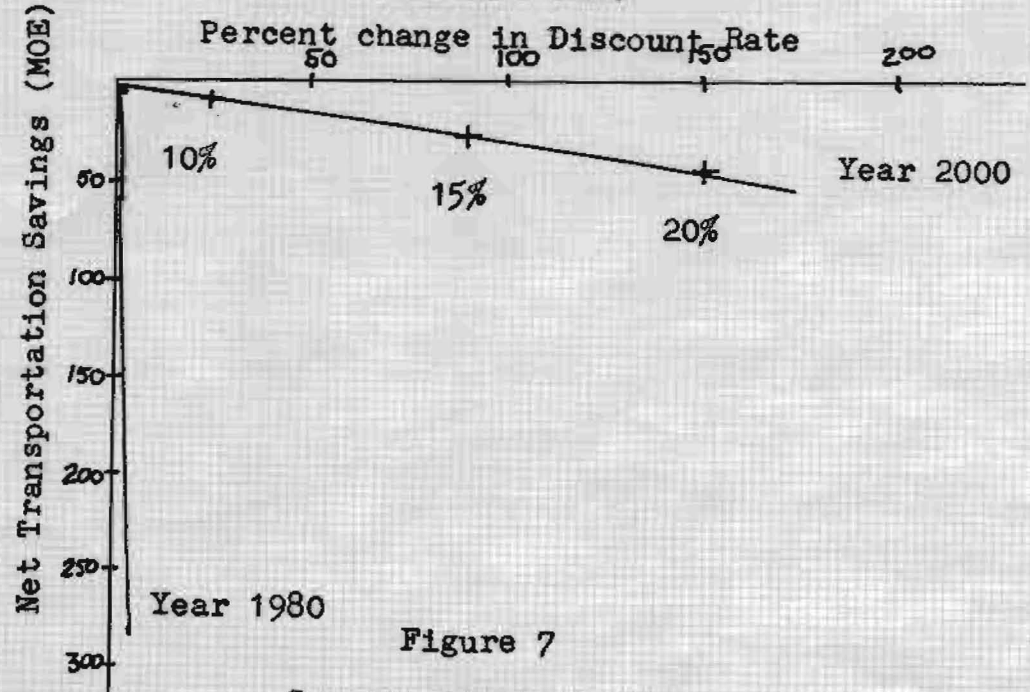
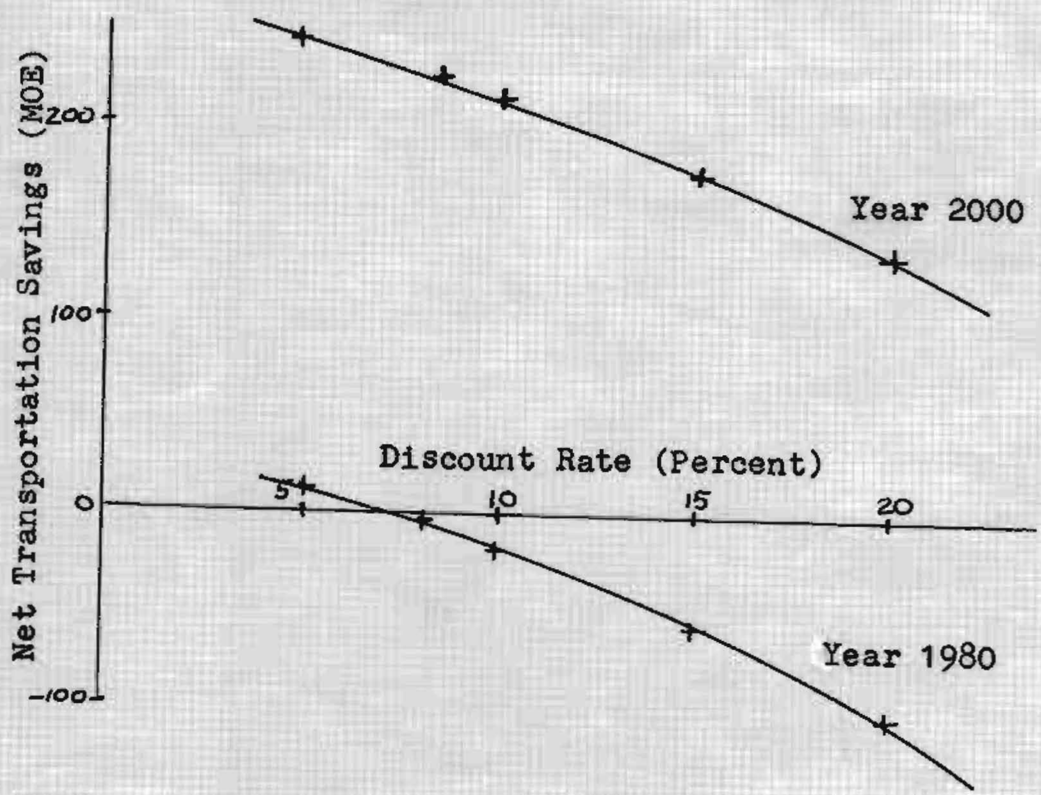


Figure 7

<u>Sensitivity Analysis</u>

Discount Rate



reduced to zero at about 7½ percent discount rate; approaching a net gain in transportation savings of $11.1 million at a discount rate of 6 percent. For a 25 percent increase in discount rate (8 to 10 percent), the net transportation savings decreased 71.7 percent and 6.5 percent for years 1980 and 2000, respectively. For year 2000, the change in discount rate was moderately sensitive. At the outset (year 1980) the discount rate is highly sensitive; decreasing in sensitivity as the throughput increases.

<u>Volume</u>

1. A volume analysis was made representing throughput volumes of 70, 80 and 90 percent (see table 15 and figure 8).

Table 15

<u>Volume Sensitivity</u>

Monobuoy Alternative

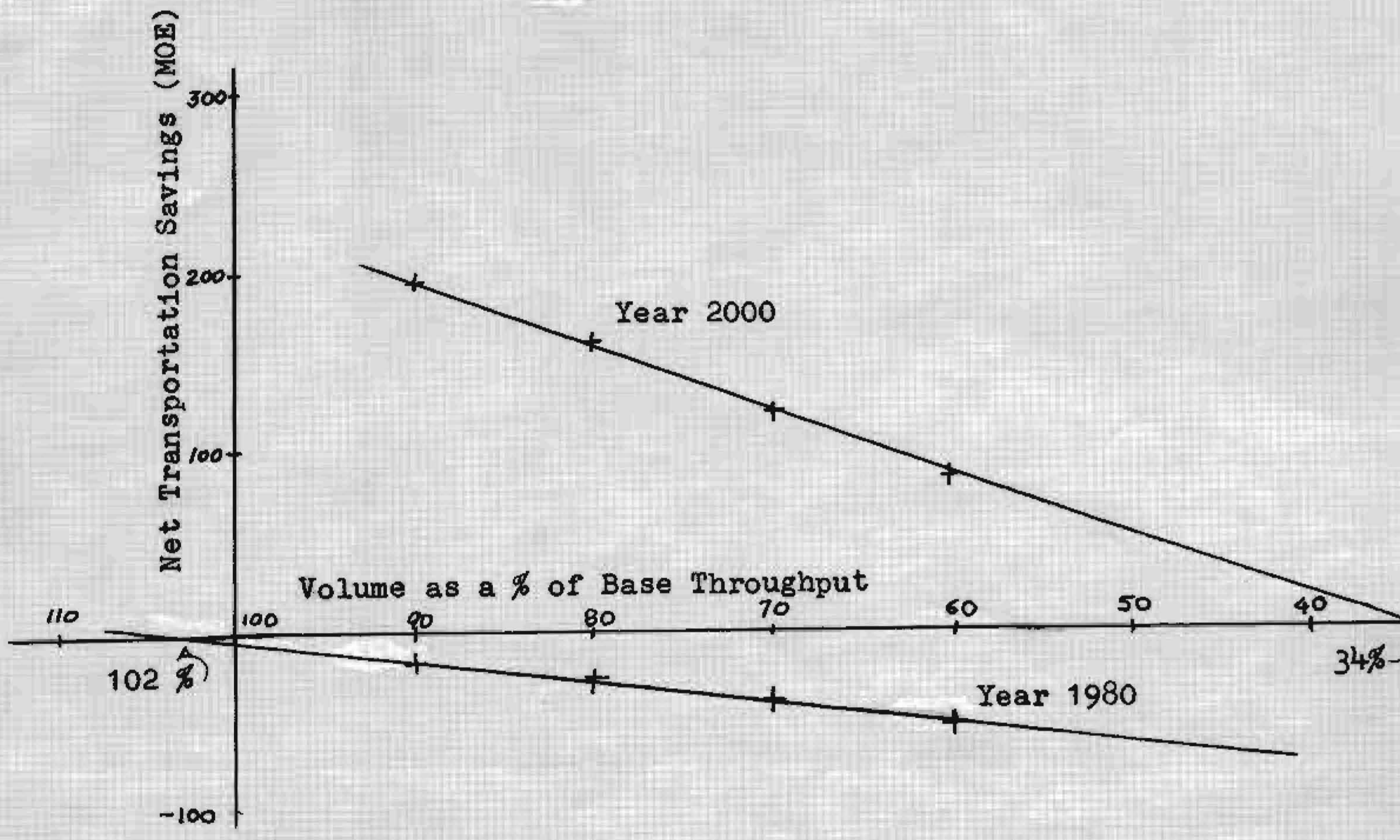
% Volume Throughput	Base Case MOC		Monobuoy MOC (x $ million)		*Net Transportation Savings (MOE)		% Change MOE	
	1980	2000	1980	2000	1980	2000	1980	2000
100%	926.6	2761.6	929.5	2530.9	- 2.9	230.7	---	---
90%	847.7	2499.2	862.1	2303.6	-14.4	195.6	596%	15.2%
80%	768.7	2236.7	795.2	2076.3	-26.5	160.4	1014%	30.5%
70%	689.8	1974.3	728.1	1849.1	-38.3	125.2	1420%	45.7%
60%	610.8	1711.8	661.0	1621.8	-50.2	90.0	1831%	60.9%

*The breakeven point for projected volume (zero net transportation savings (MOE)) occurs at 102% for year 1980 and 34% for year 2000 (see figure 8). By setting the MOC's to equal each other and solving for the percentage (789.4 x + 29 + 108.2 = 671.4 x + 65 + 193.1); x = 1.02 or 102%.

Figure 8

<u>Sensitivity Analysis</u>

Volume



The preferred monobuoy system alternative was tested. Operations and maintenance costs were held constant while annual first costs, discounted at 8 percent, were lowered according to volume of throughput reductions. As was expected, the significantly small net savings at the projected 1980 throughput was extremely sensitive with a volume reduction. A ninety percent reduction in throughput resulted in a 596 percent reduction in net transportation costs (2.9 million to a 14.4 million dollars net savings deficit). The year 2000 throughput experienced a manageable decrease in net transportation savings of 15.2 percent for a volume reduction of 90 percent. The net decreases in transportation savings are highly elastic to shortages of supply and are increasingly sensitive at low initial savings as the volume reduction is increased. The reduction in volume throughput drives the net savings to zero at approximately 34 percent of volume for year 2000. In year 1980, net transportation savings is zero at approximately 102 percent of volume throughput.

Economic Lifetime and Fleet Mix

1. The study was from the outset designed for a year 2000 projected throughput. With this in mind, varying the economic lifetime as a test for sensitivity would have been counter-productive. Similarly, with fleet mix of supertanker sizes, it was assumed that a specified range of vessel sizes would be used. The conclusions of this study would not be sensitive to the assumed fleet mix as long as the resulting expected vessel size falls within the range tested

(226,000 to 279,000 dwt). What is significant is that the cost of a deepwater monobuoy port to accomodate a 250,000 dwt tanker is not significantly less than the cost of facilities to accommodate 500,000 dwt tankers while the difference in transportation savings is significantly in favor of the larger vessel.

Environmental Effects

The Bahamas transshipment alternative would pose a more direct threat to the wetlands environment with the large number of small vessels frequenting port facilities. The probability of an oil spill is much greater than all the other alternatives considered. The dredged channel alternative would have the greatest environmental impact of facilities tested due to considerable aquatic and terrestrial habitat disruption. Additionally, the probability of oil spills directly into estuaries and marshes would be far more damaging than for offshore alternatives. The offshore alternatives would reduce the possibility of oil spills to the less probable casualty spills and malfunctioning of offloading hardware and pipeline operations. The artificial island alternative would have an impact on bottom habitats which would be somewhat small in scale. Containment of oil spills would be far more easier. The monobuoy alternatives would have little permanent impact on the environment. Primary impacts would be with casualty oil spills. Dredging operations would be transitory and short term. Overall, monobuoys appear to be the most environmentally acceptable deepwater port facility alternative.

Conclusions

This study analyzes four delivery alternatives for import of foreign crude oil in the Gulf Coast region from point of origin in the Middle East and Africa entirely in supertankers. Study conclusions are as follows:

1. Development of deepwater ports along the Gulf Coast to import foreign crude oil in large quantities is economically feasible.

2. At discount rates of 8 percent or greater, the Bahamas transshipment, artificial island and dredged channel alternatives are not economically feasible.

3. The monobuoy system is the most economically feasible deepwater port investigated. At 10 percent discount rate the average transportation savings is 3.6¢ per barrel ($98.9 million a year).

4. The three-port alternative, the Mobile-Pascagoula (Ameraport project), La Fourche (LOOP project) and Freeport (SEADOCK project) complex, is the most preferred alternative.

5. The La Fourche monobuoy complex is singularly the most cost-effective of the three-port monobuoy alternative.

6. Dispersion of import facilities would tend to maximize social and economic imports.

7. The artificial island complex should be considered further with respect to multiple uses (ie., iron ore and coal, etc.). As a single crude oil transfer terminal, it is

not economically feasible; otherwise it might be.

8. In the short run (year 1980), the foreign transshipment terminal (base case) is equally cost-effective for all practical purposes when compared with the monobuoy complex, but its cost-effectiveness diminishes as the throughput increases. Additionally, the attendant projected balance of payments deficit and relocation in refinery industry negate any visible positive considerations.

9. The environmental advantage of deepwater ports is that they not only lessen the risk of oil spills resulting from collisions and groundings, but they minimize the probability that oil spilled will reach beaches or estuaries. The monobuoy alternative also minimizes ecological disruption and is overall the most environmentally acceptable alternative.

10. A spillover benefit of the development of offshore ports is the decrease of vessel traffic density in already heavily congested harbor channels.

Notes

[1]U.S. President, Television Message, "Energy Message," CBS TV, (Washington, D.C.: 18 April 1973).

[2]U.S. President, Television Message, "Energy Message," CBS TV, (Washington, D.C.: 7 November 1973).

[3]"U.S. Energy Independence by 1980? Nixon Project Called Unrealistic," Christian Science Monitor, 28 November 1973, p. 1.

[4]"What U.S. Can Do to Tap Energy Sources Closer to Home," U.S. News and World Report, 3 December 1973, p. 25. (Hereafter referred to as What U.S. Can Do).

[5]Harry Schwartz, "Self-Sufficiency May Be Only a Mirage," New York Times, 9 December 1973, sec. E, p. 2.

[6]Editorial, Ocean Science News, 7 December 1973, p. 2.

[7]"Dirty Black Ace In the Hole," Newsweek, 12 November 1973, p. 93.

[8]"Shift to Shale," Time, 10 December 1973, p. 44.

[9]Harry B. Ellis, "Shale Fuel Still Decade Away," Christian Science Monitor, 29 November 1973, p. 6.

[10]Curtis J. Sitomer, "California May Uncork Underwater Oil Cache," Christian Science Monitor, 7 December 1973, p. 1.

[11]What U.S. Can Do.

[12]Ibid.

[13]Schwartz.

[14]Ibid.

[15]Ibid.

[16]Ibid.

[17]Ibid.

[18]What U.S. Can Do.

[19]Harry B. Ellis, "Saudis Tempt U.S. With Vast Oil Vision," Christian Science Monitor, 7 December 1973, p. 1.

[20]U.S. Department of the Interior, Deepwater Ports, Draft Environmental Impact Statement, (Washington, D.C.: June 1973), p. I - 33. (Hereafter referred to as U.S. Department of the Interior).

[21]U.S. Department of the Army, Report of Gulf Coast Deep Water Port Facilities, Texas, Louisiana, Mississippi, Alabama, and Florida (Vicksburg, Mississippi: June 1973), pp. 84-93. (Hereafter referred to as U.S. Department of the Army).

[22]U.S. Department of the Interior, p. II-36.

[23]Ibid., p. II-20.

[24]Ibid., p. I-1.

[25]James L. Kelley, "Offshore Terminal and the National Perspective," Ninth Marine Technology Society Proceedings (1973), p. 10.

[26]U.S. Department of the Interior, pp. I-37,38.

[27]U.S. Department of the Army, pp. 84-93.

[28]John Mascenik, "Offshore Deepwater Crude-Oil Terminals," Oil and Gas Journal (5 March 1973), p. 10.

[29]U.S. Department of the Army, p. 14.

[30]Mascenik, p. 105.

[31]U.S. Department of the Interior, pp. I-35,36.

[32]U.S. Department of the Army, p. 12.

[33]John Pisani, Robert Wordwell and Robert Bryan, "Progress in World Wide Deepwater Port Development - Why the United States Is Lagging," Presentation, American Society of Mechanical Engineers Conference (Los Angeles, California: 16-20 September 1973), p. 6.

[34]Gary H. Knight, "International Legal Aspects of Deep Draft Harbor Facilities," Journal of Maritime Law and Commerce (April 1973), pp. 376,377.

[35]"Gloptik Tokyo, Largest Ship in the World," Shipping World and Shipbuilding (June 1973), pp. 595-598.

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