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A STUDY OF THE UNITED STATES OIL PORTS AND THEIR CAPACITIES TO ACCOMMODATE THE WORLD'S TANKSHIP FLEET

ROGER H. RUHSENBERGER

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By

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Is the program of harbor development in the United States keeping pace with the yearly increases in the sizes of the world's tankers? During the 1960's, the World War II tankers will reach their normal retirement age of twenty years. These T-2 tankers are, for reasons of economy and operating efficiency, being replaced by ships well in excess of 30,000 deadweight tons. The purpose of this paper is to investigate the navigational limitations placed on tankers, by the harbor conditions of various United States oil ports. Several recommended courses of action are presented, in an attempt to assist in solving the problem of the increasing inadequacy of the majority of the U. S. ports, to effectively handle tankers in excess of 30,000 dwt. If the United States is to maintain its position as a world maritime power, our harbors and terminal facilities must keep pace with the ships they service.

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A STUDY OF THE UNITED STATES OIL PORTS AND THEIR CAPACITIES TO ACCOMODATE THE WORLD'S TANKSHIP FLEET

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By

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May 1962

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INTRODUCTION

In 1959, the world's tanker fleets broke the 100,000 deadweight ton barrier with the launching of the S. S. "Universe Apollo". By 1961, three other tankers in excess of 100,000 dwt had either been launched, or were on the ways. This is a far cry from the World War II, T-2 type tanker of 16,000 dwt. This increase in deadweight tonnage of ships is not necessarily surprising, as it is a continuation of the trend in the construction of larger and larger tankers since the end of World War II. With the growing rise in size in the world's tankers, the obvious question that must be answered is; are the ports at which these ships call, presently capable of effectively handling a "super-sized" tanker? The purpose of this report will seek to supply an answer to this question.

This paper will basically be presented in three parts. Chapter I will discuss the development of the tanker from its birth in 1883, up to the present time. The present and future trends in the construction of super tankers will also be discussed. For the purpose of this report, the term "super-sized" tankers will include tankers in excess of 30,000 deadweight tons.

Chapter II will be a survey of the major sea ports of the United States; tieing in the respective existing harbor facilities, to what is required to handle effectively a super-sized tanker.

The demand for petroleum products in the United States, together with a few of the basic reasons for the desire of shipping companies to incorporate super-sized tankers into their respective fleets, will

be discussed in Chapter III.

The conclusions of this paper will attempt to present several alternatives as to the desirability of major harbor development, establishing off-shore terminals, or the limited usage of super-sized tankers in the importing and exporting of petroleum products through U. S. ports.

CHAPTER I

TANKER FLEETS OF THE WORLD

Birth of the Tanker

In the mid 1800's, a Frenchman, by the name of Etienne Lenoir, invented the first practical internal combustion engine. While this in itself was of notable acheivement, Lenoir brought about a new age for the world, one that will live at least as long as friction is a problem to mankind. This age was to become known as the age of petroleum. As the mechanization of the world progressed, the need for petroleum products became greater and greater. As a result, the countries of the world could no longer effectively supply their demands from within. Out of necessity, the world turned to the sea and a new enterprise was born; the transportation of large quantities of petroleum in bulk over the "seven seas".

Prior to 1886, the tankers of the world were ships of sail carrying "barreled oil". In 1886, the first ocean-going steam tanker was built in England. A German, Wilhelm A. Riedemann, conceived and supervised the construction of the tanker "Gluckhauf". This vessel was 300.5 feet long, had a beam of 36.2 feet, a draft of 26.2 feet, with a deadweight tonnage of 3,020 tons. In 1888, John Roach of Chester, Pennsylvania, built for the Standard Oil Company, the 4,400 dwt tanker S.S. "Standard". This was the first steam tanker to be built in the United States.[1]

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[1]Captain Milton Breece and Captain James G. Moffitt, "Compar-

From that time until 1930, tank vessel sizes increased slowly, reaching an average size of from 11,000 to 12,500 deadweight tons. There were, of course, exceptions to this slow increase; most notable of these exceptions were the S.S. "John D. Archbold", built in 1921, of 22,600 dwt and the S.S. "C. O. Stillman", 1928, of 24,000 dwt.[2]

During the period 1930-1939, the U. S. tanker fleet grew to a total deadweight tonnage of 4,282,000 tons, however the average size remained in the 11,000 to 12,500 dwt class. In 1939, a paper presented to the Society of Naval Architects and Marine Engineers, concerned primarily with the saving in steel weight brought about by the advent of welding in the construction of tankers, mentions maximum size tankers of 15,000 to 16,000 dwt, however these again were notable exceptions.[3]

World War II

With the advent of World War II, the urgent need for petroleum products for the support of our Armed Forces became immense. Over half of all the tonnage of supplies, which was shipped overseas during World War II, was petroleum. More than 400 different petroleum products were regularly used by the armed services. To supply our vast military

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ison of U.S. and Foreign Port Development and Large Ship Effects in Restricted Channels" (paper presented at a Session of the Annual Tanker Conference of the Central Committee on Transportation by Water and its Associated Committees of the Division of Transportation of the American Petroleum Institute, Cape Cod, Massachusetts, June 14, 1961).

[2] Ibid.

[3] N. J. Pluymert, "Modern Tanker Design", Transaction SNAME, Vol. 47, 1939.

forces, widely separated in Europe and in the Pacific, and to reduce the vulnerability of our petroleum supply lines to submarine attack, it was obvious that the mass production of larger and faster tankers would be required. To meet this need, the U.S. Maritime Commission designed and constructed the T-2 type tanker. Approximately 525 of the T-2 tankers, representing 72% of the U.S. flag tanker tonnage built during the years of World War II, were launched.

The design characteristics of the T-2 tanker are shown below in Table I.

TABLE I

DESIGN CHARACTERISTICS OF THE T-2 TYPE TANKER

Length	523-6
Beam	68-0
Draft (summer load line)	30-2
Deadweight Tonnage	16,600
Speed	14.5 kts.

Post World War II

By the end of World War II, it was the general belief that an excess number of tankers would exist, due to the vast wartime construction program carried out by the Allies. However, an unexpected demand for petroleum developed in the period 1946-48, and the World War II, T-2 tankers were not in sufficient quantity to satisfy the world's need for tankers. As a result, a new program of tanker construction was

initiated by the world's major oil companies and independent owners. In the two calendar years 1947-48 alone, American shipyards received orders for 71 tankers totaling approximately 1,700,00 dwt.[4]

The tanker construction program continued the trend towards vessels of greater and progressively greater size. In 1948, another report delivered to the Society of Naval Architects and Marine Engineers, gave a very comprehensive collection of data on a large number of tankers. The largest tanker mentioned was of 30,000 dwt.[5] This birth of the "super-tanker" was of notable acheivement as with only a two foot increase in draft over that of the World War II, T-2 tanker, the super-tanker could carry 80% more cargo.[6] This was the first of many numerous strides taken towards more efficient ocean petroleum carriers.

During 1951, the western boycott of Iranian oil and the virtual shutdown of the Abadan refinery, eliminated the source of 7% of the non-Soviet world's crude petroleum and more than 25% of all refined products supplied outside the Western Hemisphere. It became necessary for other areas of the Middle East and the Western Hemisphere to increase their crude oil production. A major share of the burden of meeting the

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[4] John George Glover and Rudolph L. Lagai (ed.), The Shipbuilding, Ship Repair and Shipping Industries, reprinted from The Development of American Industries-Fourth Edition. New York: Simmons-Boardman Publishing Corporation, 1958. p.24.

[5] Messrs. Robinson, Roeske and Thaeler, "Modern Tankers", Transactions SNAME, Vol. 56, 1948.

[6] Loren F. Kahle and A. J. Kelly, "Development of the Modern Oil Tanker," Marine Engineering/Log, LXIV No.8 (July, 1959),68.

shortage of refined products was met by U. S. refineries and shipping. This increase in the problem of petroleum supply brought an additional demand for larger and more efficient carriers. As a result, the tanker construction program of 1951-52 resulted in the construction of tankers with an average of 25,000 deadweight tons.

Even with the expanded shipbuilding program of the 1951-52 period, the world demand for oil tankers was still out-running the supply. The basic reason for this was that the world's consumption of oil was doubling approximately every ten years. The concern over the world tanker shortage is becoming more evident by the growing realization that the Suez Canal, which is an important link in the flow of oil, is rapidly becoming inadequate in handling the ever increasing flow of traffic.

The need for larger tankers was further demonstrated by the blockage of the Suez Canal and the destruction of the Iraq Petroleum Company's pipeline pumping stations in Syria following the Anglo-French-Israeli attack on Egypt in 1956. This crisis cut off two-third's of the immediate flow of oil to Europe, and required an organized international effort to supply oil to Western Europe. The greater part of the resulting shortage was met by increased Western Hemisphere shipments and the world wide rerouting of tankers.

With the Suez Canal in operation, practically no oil was routed to Europe around the Cape of Good Hope. With the closing of the normal route, the entire supply of oil from the Middle East ports was required to be rerouted to Europe via the Cape of Good Hope. It was determined that one tanker of the 50,000 dwt class and over, could transport petroleum by way of the Cape much more economically and quicker, than three

World War II, standard T-2 type tankers.

There are many who feel that the closing of the Suez Canal actually triggered the trend towards larger vessels. During the $1\frac{1}{2}$ years ending 30 June 1957, 36 tank vessels, with an average size of 40,000 dwt, were ordered in the United States alone.[7] With the reopening of the Suez Canal, rather than an expected reduction in the desire for large tankers, the trend to build tankers of larger deadweight tonnages remained.

As of October 1958, approximately 77% of the world's tanker fleet was composed of vessels under 30,000 dwt. Of the remaining 23% in excess of 30,000 dwt, only 12 tankers were larger than 50,000 dwt. However, nearly 80% of the tonnage on order or under construction by the end of 1958 was in excess of 30,000 dwt. The average size of this new construction was 35,000 dwt. By the end of the calendar year 1959, of the 2,985 tankers in the world fleet, 154 were in excess of 40,000 dwt. In addition, of the 479 tank vessels on order or under construction, 237 were in excess of 40,000 dwt. By the end of 1960, the total number of vessels in excess of 30,000 dwt, stood at 576, with two in excess of 100,000dwt (Table II). For the growth analysis of the world's merchant tankers from prior to 1938 up to 1960, in graph form, see Table III.

Future Outlook

By 1965, there will be a total of 961 tankers in the world's fleet, that will have individual ages in excess of twenty years. This

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[7] Glover and Lagai, loc. cit.

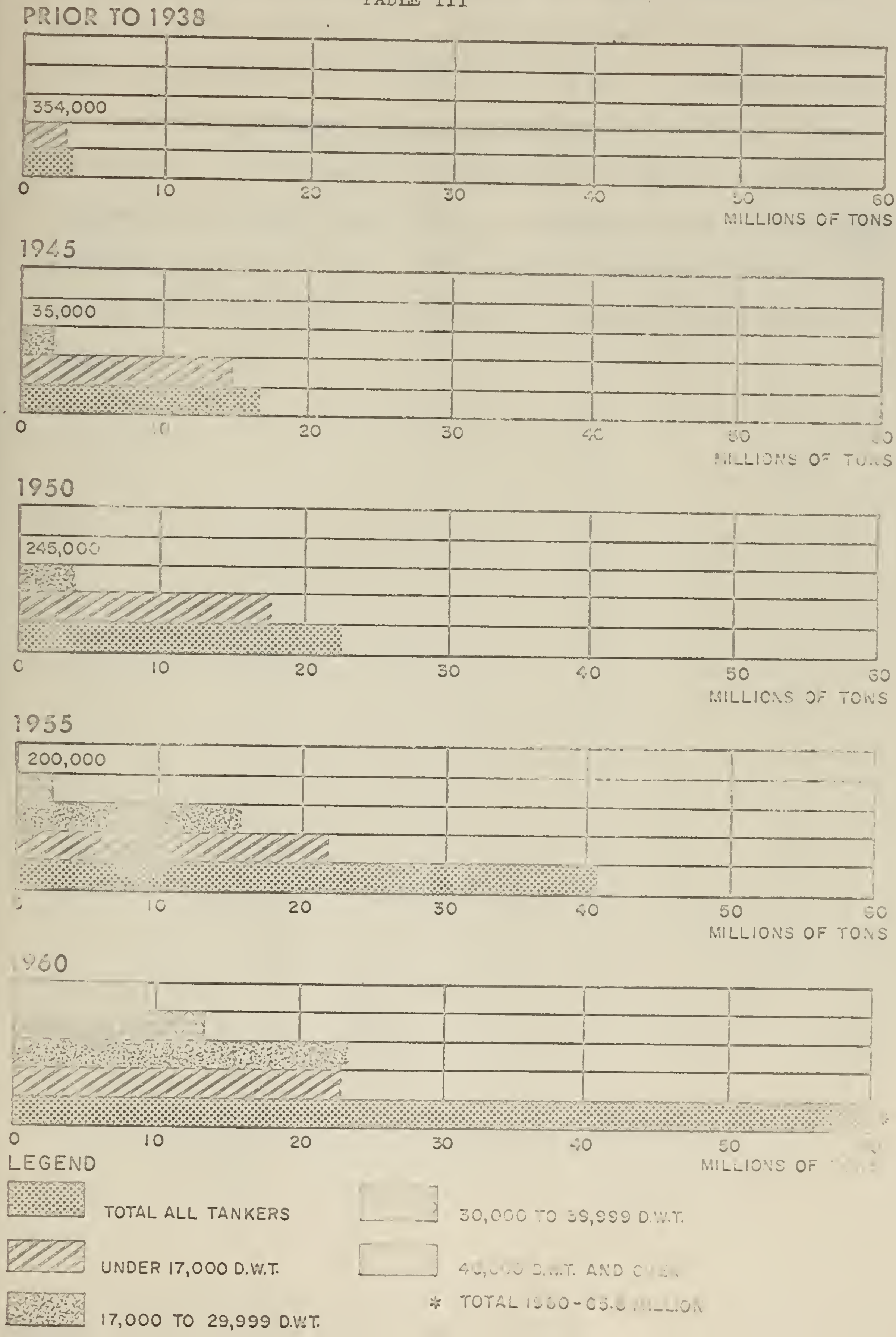
TABLE II

DEADWEIGHT TONNAGE GROUPS OF THE WORLD TANK SHIP FLEET
AS OF DECEMBER 31, 1960
(OCEAN-GOING VESSELS 2,000 DEADWEIGHT TONS AND OVER)

DEADWEIGHT TONNAGE GROUPS (IN THOUSANDS)	TOTAL WORLD NUMBER	TOTAL WORLD D.W.T.	CUMULATIVE PERCENTAGE (OF TOTAL DWT)
Under 10	344	1,839,400	2.8%
10 to 15	464	5,789,600	11.6
15 to 16	146	2,274,900	15.0
16 to 17	618	10,186,800	30.5
17 to 18	130	2,284,300	34.0
18 to 19	308	5,643,000	42.6
19 to 20	215	4,181,800	48.9
20 to 25	258	5,717,800	57.6
25 to 30	205	5,658,200	66.2
30 to 35	270	8,728,300	79.5
35 to 40	118	4,391,100	86.2
40 to 45	74	3,055,900	90.9
45 to 50	81	3,793,900	96.7
50 to 60	11	567,500	97.5
60 to 70	11	712,500	98.6
70 to 80	2	145,000	98.8
80 to 90	7	598,900	99.7
90 to 100	-	-	
100 to 110	2	211,500	100.0
TOTALS	3,264	65,780,400 DWT	

WORLD MERCHANT TYPE TANKERS

TABLE III



twenty year figure represents the normal life span of today's tanker. The replacement of this carrying capacity, plus the ever growing demand rate for petroleum, will quite obviously, be met by a continuing tanker construction program. It can be expected that the trend in the construction in super-tankers will continue. By way of an example, the tank vessels under construction or contracted for as of 1 July 1961, are shown in Table IV. It is of interest to note that tankers in excess of 30,000 dwt represent 75.7% of the total of the 331 ships on order.

TABLE IV

TANK VESSELS UNDER CONSTRUCTION OR CONTRACTED FOR AS OF 1 JULY 1961

DEADWEIGHT TONNAGE (IN THOUSANDS)	NUMBER OF SHIPS	TOTAL TONNAGE BY CLASS	PERCENT OF TOTAL TONNAGE	CUMULATIVE PERCENT (OF TOTAL TONNAGE)
UNDER 10	9	72,000	00.6%	00.6%
10 to 15	2	25,000	00.2	00.8
15 to 20	38	665,000	04.7	05.5
20 to 25	19	427,500	03.0	08.5
25 to 30	13	292,500	02.0	10.5
30 to 35	41	1,332,500	09.5	20.0
35 to 40	20	750,000	05.3	25.3
40 to 45	28	1,190,000	08.4	33.7
45 to 50	79	3,752,500	26.6	60.3
50 to 60	32	1,760,000	12.5	72.8
60 to 70	22	1,430,000	10.2	83.0
70 to 80	10	750,000	05.3	88.3
80 to 90	14	1,190,000	08.4	96.7
90 to 99	1	95,000	00.7	97.4
100 AND OVER	3	366,000	02.6	100.0
TOTALS	331	14,098,000 DWT		

CHAPTER II

OIL PORTS OF THE UNITED STATES

With the maritime fleets of the world, following the trend towards increased ship dimensions, the obvious question of prime importance to any maritime nation is, one of whether its' respective deep-water harbors and facilities are capable of handling these ships. If this size trend continues in an upward direction, with the replacement of retiring ships, with ships of larger and progressively larger sizes; the answer to such a question could, quite obviously, greatly effect the future of a nation as a maritime power.

While the primary purpose of this paper is a survey of the world's tanker fleets versus the existing harbor conditions of the United States, harbor restrictions and limitations discussed in this chapter are equally applicable to all classes of merchant ships. This is due primarily to the fact that, taking the world's maritime fleets and shipbuilding program as a whole, the area of tanker construction and the world's tankers presently in use, constitute by far the largest ships, both from the standpoint of length and draft.

In the review of the sea ports of the United States, the selection of the harbors used was based principally on the information contained in "Ports of the World" (14th Edition)[1] and "The United States

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[1] Donald Maxwell (ed.), Ports of the World (14th Edition; London: The Shipping World Limited, 1960), pp. 115-248.

Coast Pilot Series".[2] Only those ports which listed petroleum and/or petroleum products as imports or exports have been used.

The description of each port contains such information as:

1. Natural harbor entrance restrictions - ice conditions, adverse conditions at the entrance bar, due to tidal and weather effects, etc.
2. Description of main ship channel - unless otherwise specified, all depths given are minimum depths at mean low water.
3. Anchorages - given where appropriate. Unless otherwise specified, depths are minimum depths at mean low water.
4. Berthing conditions - except where otherwise specified, all depths are minimum depths at mean low water. When available, existing pier lengths have been indicated, however this report is not primarily concerned with existing pier facilities. The reason for the lack of emphasis on pier length is due to the fact that, it is not necessary for a pier to even approach the length of ships to be accomodated.
5. Additional information such as maneuvering room, range of tide, and the availability of pilots and tugs is also included, where appropriate.

After each description, there has been indicated, what this author considers to be the principal limiting navigational factors, re-

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[2]The United States Department of Commerce, <u>The United States Coast Pilot</u>: <u>1960</u>. Vols. 1-5,7 (Washington: Government Printing Office, 1960).

stricting or limiting the size of ships capable of being accomodated by that port.

Following these restrictions and limitations, the maximum size tanker class presently capable of being accomodated is given (Table V). (A table of draft analysis of the World Tankship Fleet has also been included in this chapter to show the percentage of ships divided by draft groups - Table VI.) For the purpose of this report, the classes indicated are considered to be loaded to the summer load line. A safety factor of five feet has been added to the drafts of the various classes. This factor is taken into consideration as an allowance for the increased draft caused by rolling and squat of vessels.[3] In determining the maximum size tanker that can safely transit a channel, the range of the tide, where appropriate, has been taken into consideration.

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[3] Squat is defined as the tendency of a vessel underway to actually float in a reduced level caused by the motion of the vessel. For a discussion of the effects on draft caused by rolling and squat see; "Comparison of U. S. and Foreign Port Development and Large Ship Effects in Restricted Channels", by Capt. M. Breece and Capt. J. G. Moffitt, presented to the API Annual Tanker Conference, Cape Cod, Mass., on June 14, 1961. In this paper, the authors recommend a safety factor of 10 to 12 feet, but also state that due to the controling depths of many harbors, this figure is not realistic.

As increased draft due to rolling and squat is a recognized tendency of ships, a good ship master should be aware of this possible increase and handle his ship accordingly; either delay entering a channel until swells diminish or adjust speed as necessary to prevent squat grounding.

Therefore I have recommended a safety factor of only 5 feet, which should, under normal conditions, using good seaman's sense, allow a reasonable margin for safety. Shiphandlers must realize that with abnormal conditions their actions must be governed accordingly, to give the greatest measure of safety to the ship, crew, and cargo.

TABLE V

AVERAGE TANK VESSEL DRAFT BY DEADWEIGHT TONNAGE
(LOADED TO SUMMER LOAD LINE)

DRAFT	DEADWEIGHT TONNAGE MINIMUM	DEADWEIGHT TONNAGE MAXIMUM
20 FEET AND UNDER	-	4,000
20 to 25	4,100	8,000
25 to 30	8,100	15,000
30 to 35	15,100	32,000
35 to 40	32,100	50,000
40 to 45	50,100	71,000
45 FEET AND OVER	71,100	-

TABLE VI

DRAFT ANALYSIS OF WORLD TANKSHIP FLEET
AS OF DECEMBER 31, 1960
(OCEAN-GOING VESSELS 2,000 DWT AND OVER)

DRAFT	NUMBER OF SHIPS	PERCENTAGE	CUMULATIVE PERCENTAGE
15 FEET AND UNDER	25	00.7%	00.7%
15 to 20	137	4.2	4.9
20 to 25	113	3.5	8.4
25 to 30	641	19.6	28.0
30 to 35	1,901	58.2	86.2
35 to 40	420	12.9	99.1
40 to 45	17	00.5	99.6
45 FEET AND OVER	10	00.4	100.0
TOTAL	3,264		

I. ATLANTIC COAST

Bangor, Maine

The entrance is closed by ice during the winter season. Bangor is located about 24 miles up from the mouth of the Penobscot River. The controlling depth of the river channel is 14 feet, however due to a range of tide of 13 feet, vessels drawing 23 feet can make Bangor on a flood tide. Due to a narrow channel and restricted depth, maneuverability is limited. Vessels bound up the river, anchor anywhere in the channel where soft mud is found. Most of the river in front of the city has been dredged where necessary, to obtain a depth of 14 feet minimum. There are 21 wharves with a minimum depth of 14 feet. Pilots and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of river channel - 14 feet.
2. Narrow channel - restricting maneuverability.
3. Depth of water at piers - 14 feet.

Maximum size of tankers that can safely be accomodated:

5,000 dwt (on flood tide only) representing 6.5% of the ocean-going tankers 2,000 dwt and over.

Bucksport, Maine

There are no natural harbor entrance restrictions. The port of Bucksport is located about 6 miles above the entrance to the Penobscot River. The controlling depth of the river is 20 feet, however due to a range of tide of 11 feet, vessels drawing as much as 30 feet, have

been accomodated on a flood tide. Numerous anchorages are available below the entrance to the Penobscot River, with depths of water ranging up to 72 feet. Vessels bound up the river anchor anywhere in the channel, where soft bottom is found. The petroleum handling berth, consisting of 5 concrete pile clusters supporting a handling platform, provides a berth 700 feet long, with an alongside depth of 35 feet. Local pilots are available, however tugs must be arranged for, from Bangor.

Principal limiting navigational factors:

1. The controlling depth of the river - 20 feet.
2. Lack of local tugs available to assist large shallow draft vessels.

Maximum size of tankers that can safely be accomodated:

15,000 dwt (on flood tide only), representing 28% of the ocean-going tankers 2,000 dwt and over.

Searsport, Maine

There are no natural harbor entrance restrictions. Searsport is located at the head of the Penobscot Bay, with channel depths ranging from 25 to 40 feet. Numerous anchorages are available with depths ranging from 13 to 40 feet, with a soft bottom. Ample maneuvering room is available. Four piers are maintained; Searsport Terminal - 32 feet alongside, coal pier - 20 to 35 feet alongside, railroad wharf - 30 feet alongside, and an oil pier - 20 to 35 feet alongside. Range of the tide is 10 feet. Pilots and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside piers - 20 to 35 feet.

2. Depth of channel - minimum 25 feet.

Maximum size tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers over 2,000 dwt.

Bath, Maine

There are no natural harbor entrance restrictions. Bath is located 12 miles above the entrance to the Kennebec River. The principle dangers in the river are marked, but in places the channel narrows to 100 yards. Minimum channel depth is 25 feet. Suitable anchorages are available at Bath, in waters from 25 to 30 feet deep. The deepwater berths have depths alongside ranging from 25 to 30 feet. Range of the tide is 6 feet. Local pilots are available (pilots will take ships up to 30 foot drafts at proper tides). There are no local tugs available. They must be obtained from Portland if necessary.

Principal limiting navigational factors:

1. Controlling depth of channel - 25 feet.

2. Depth of water at berths - 25 to 30 feet.

3. Lack of local tugs available to assist large shallow draft vessels.

Maximum size of tankers that can safely be accomodated:

15,000 dwt (flood tide only), representing 28% of the ocean-going tankers 2,000 dwt and over.

Portland, Maine

There are no natural harbor entrance restrictions. Main entrance channel is 3.5 miles long, 1,100 feet wide, with a depth of 35 feet. Ample anchorage area is available, with depths ranging from 25 to in excess of 40 feet. There are 8 oil handling berths for deep draft tankers, with depths alongside ranging from 30 to 35 feet. In the outer harbor, there is an oil handling berth with 42 feet alongside. Range of the tide is 8 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of main channel - 35 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Portsmouth, New Hampshire

There are no natural harbor entrance restrictions. Situated on the Piscataqua River, about 4 miles above the entrance to the harbor. The main channel has a controlling depth of 35 feet. Several anchorages are available in depths ranging up to 66 feet. The harbor is open throughout the year and is of sufficient draft to accomodate large deep draft ships, however they are hampered somewhat in passing through the two lift bridges over the main channel, to deepwater berths above the city. There are several oil berths with 35 feet of water alongside. Range of the tide is 8 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel - 35 feet.

2. Depth of water alongside oil piers - 35 feet.

3. Maneuverability to deep water piers restricted by two lift bridges over the main channel.

Maximum size of tankers that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Glouster, Massachusetts

There are no natural harbor entrance restrictions. The main entrance channel has a width of 1,500 feet, with a minimum depth of 30 feet. There is ample maneuvering room. The most frequently used anchorage is in the outer harbor with depths of from 24 to 36 feet. Glouster has a great many wharves, however most of them are used in connection with fishing industries. Water alongside varies up to 22 feet. Range of tide is 9 feet. Pilots are compulsory and tugs are available from Boston.

Principal limiting navigational factors:

1. Controlling depth of main channel - 30 feet.

2. Depth of water alongside piers - maximum 22 feet.

Maximum size of tanker that can safely be accomodated:

8,000 dwt (flood tide only), representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Boston, Massachusetts

There are no natural harbor entrance restrictions. The principle entrance to Boston Harbor is 1,500 feet wide. The eastern 990 feet width of the channel has been dredged to 40 feet and the western 600 feet has been dredged to 35 feet. This channel leads to the Boston outer harbor, which is 6,000 feet long and 2,000 feet wide, with depths varying from 30 to 60 feet. The inner harbor, where the principle commercial center is located, is connected with the outer harbor by a channel 600 to 1,200 feet wide, with depths of from 35 to 40 feet. Boston has about 140 miles of berthing space, of which 8 miles front on a depth of 30 feet, and over 7 miles front on a depth of 35 feet. A depth of 40 feet is available at Commonwealth Pier Number 5, on the South Boston waterfront. Range of tide is 10 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth alongside majority of deepwater piers - 35 feet.

Maximum size of tanker that can safely be accomodated:

50,000 dwt, representing 99.1% of the ocean-going tankers 2,000 dwt and over.

New Bedford, Massachusetts

There are no natural harbor entrance restrictions. The main entrance channel is 350 feet wide with a controlling depth of 30 feet. The channel has been increased in width at several locations for anchorage and maneuvering purposes. Deepwater berths are at the State Pier,

with a maximum berth length of 775 feet. Depths of water alongside piers is maintained at 30 feet. Range of tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of main channel and alongside piers - 30 feet.

Maximum size of tanker that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Fall River, Massachusetts

There are no natural harbor entrance restrictions. The main channel from the sea to Fall River has a controlling depth of 35 feet, with a minimum width of 400 feet. There are no designated anchorages in Fall River harbor, however there are ample anchorages off the main channel with depths of from 25 to 35 feet. Ample maneuvering room is available. The wharves and piers at Fall River afford over 9,000 feet of berthing space with deepwater berths having from 35 to 85 feet of water alongside. Range of the tide is 4 feet. Pilots are compulsory and tugboats are available from Newport or Providence.

Principal limiting navigational factors:

1. Controlling depth of main channel - 35 feet.

Maximum size tankers that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Providence, Rhode Island

There are no natural harbor entrance restrictions. Providence is situated about 7 miles above the entrance to the Providence River. The limiting depth of the main channel is 35 feet. This channel varies from 600 to 1,700 feet in width. There are numerous piers ranging in length up to 4,200 feet, with depths alongside of 35 feet. Numerous anchorages are available, with depths of at least 30 to 35 feet. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of main channel and alongside piers - 35 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

New London, Connecticut

There are no natural harbor entrance restrictions. Main entrance channel is 3.8 miles long, 600 feet wide with a controlling depth of 33 feet. Skirting the waterfront is a channel 400 feet wide with a depth of 25 feet. Several anchorage areas are available with depths ranging from 25 to 30 feet. Ample maneuvering room is available. There are 11 petroleum piers with depths alongside ranging from 30 to 35 feet. Range of the tide is 3 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of main entrance channel - 33 feet.

2. Depth of channel skirting waterfront - 25 feet.

3. Depth of water alongside petroleum piers - 30 to 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

New Haven, Connecticut

There are no natural harbor entrance restrictions. The main entrance channel is 400 feet wide, with a controlling depth of 35 feet. Several anchorage areas are available with depths of from 20 to 25 feet. A channel has been dredged from the main channel to the oil pier, with a controlling depth of between 25 and 30 feet. Range of the tide is 6 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel to oil pier - 25 to 30 feet.

2. Depth of available anchorages - 20 to 25 feet.

Maximum size of tanker that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Bridgeport, Connecticut

There are no natural harbor entrance restrictions. Entrance channel varies in width from 400 to 700 feet, with a minimum depth of 30 feet. Anchorages are available with a depth of 25 feet. The deep-

water berths at the Cilco Terminal, have a minimum depth of 30 feet. Range of the tide is 7 feet. Pilots are compulsory and tugs are available from New York City.

Principal limiting navigational factors:

1. Controlling depth of main channel and alongside piers - 30 feet.

Maximum size of tanker that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

New York, New York

There are no natural harbor entrance restrictions. Ambrose Channel, the principle entrance to New York Harbor, is 2,000 feet wide, with a controlling depth of 44 feet. Intraport channels range in depth from 30 to 34 feet. Total number of berths exceed 400. Developed water-frontage measured aroung piers and head of slips totals 755 miles. For overseas traffic, piers of a length exceeding 450 feet, and with water depths exceeding 25 feet, number 130. Numerous anchorages are available with depths well in excess of 40 feet. Range of the tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

None.

Maximum size of tanker that can safely be accomodated:

At present, the channel depth and berthing facilities are capable of effectively handling the largest of the super-sized tankers.

Port Newark, New Jersey

There are no natural harbor entrance restrictions. Port Newark is a deep sea port within the Port of New York. The entrance channel is 7,000 feet long and 685 feet wide with a minimum depth of 35 feet. There are no anchorages available at Newark. Nearest anchorage is at Staten Island, approximately 5 miles away, with minimum depths of 35 feet. There are 28 deepwater berths with 35 to 40 feet of water alongside. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel - 35 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Albany, New York

There are no natural harbor entrance restrictions. Ice breakers are assigned when needed during the winter months. The controlling depth of the Hudson River from New York to Albany is 27 feet, with a minimum bottom width of 300 feet. The restricted width of the river at Albany is not sufficient to permit vessels to swing at anchor, without interfering with passing craft. The Port of Albany has 30 modern well-equipped wharves, with a total of 18,600 feet of berthing space, having depths up to 28 feet alongside. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of the river and water alongside berths - 27 feet.

2. Limited maneuvering room.

Maximum size of tanker that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Camden, New Jersey

There are no natural harbor entrance restrictions. Located about 87 miles above the Delaware Cape, with a main channel 800 to 1,000 feet wide with a controlling depth of 40 feet up to the Philadelphia Naval Shipyard. From the Naval Shipyard to Camden, the channel is 800 feet wide with a depth of 37 feet. Anchorages with a controlling depth from 18 to 37 feet are available. There is limited maneuvering room, due to the 800 foot wide channel and heavy traffic. The Camden Marine Terminals are marginal type wharves, with a berthing space of 1,100 feet, and have a controlling depth of 30 to 35 feet alongside. Range of the tide is 6 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of main channel - 37 feet.

2. Depth of water alongside piers - 30 to 35 feet.

3. Width of channel - 800 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Philadelphia, Pennsylvania

There are no natural harbor entrance restrictions. Philadelphia is located at the junction of the Delaware and Schulykill Rivers, 87 miles above the Delaware Capes. The channel from the Delaware Bay to the Philadelphia Naval Shipyard is from 800 to 1,000 feet wide and 40 feet deep. The channel from the Naval Shipyard to Allegheny Avenue, which serves the majority of the deepwater berths, is 800 feet wide with a depth of 37 feet. Various anchorages are available with a minimum depth of 35 feet. There are 381 wharves of various sizes, which provide berthing space for 147 deep draft vessels. Greatest alongside depth is 40 feet. Range of the tide is 6 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of channel - 37 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Chester, Pennsylvania

There are no natural harbor entrance restrictions. Chester is located 72 miles above the Delaware Capes, with a main ship chan-

nel 800 to 1,000 feet wide, with a controlling depth of 40 feet. Anchorages, with a controlling depth of from 18 to 37 feet, are available. There is limited maneuvering room, due to the combination of channel width and heavy traffic. The Chester Tidewater Terminal has a depth alongside of 35 feet, however, the majority of the remaining wharves at Chester have depths of from 15 to 20 feet alongside. Range of the tide is 5 feet. The largest type tankers, that have normally been accomodated at this port in the past, have had a length overall of 450 feet and a draft of 25 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside piers; one terminal - 35 feet, all others - 15 to 20 feet.
2. Width of channel - 800 feet, with heavy traffic.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Wilmington, Delaware

There are no natural harbor entrance restrictions. Wilmington is located on the Christina River, 64 miles above the Delaware Capes. The main channel up the Delaware River is 800 to 1,000 feet wide, with a depth of 40 feet. The channel up the Christina

River is 400 feet wide, with a depth of 36 feet. Anchorages are available in the Delaware River, with depths up to 40 feet, however, no anchorages are available in the Christina River. Wilmington Marine Terminal has a quay 2,060 feet in length, with a depth alongside of 36 feet. Range of the tide is 5 feet. Pilots are compulsory and tugs are available from Philadelphia.

Principal limiting navigational factors:

1. Controlling depth of the Christina River channel - 36 feet.
2. Limited maneuvering room, due to width of the Christina River channel - 400 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Baltimore, Maryland

There are no natural harbor entrance restrictions. The main entrance channel is 20 miles long, 600 feet wide, with a controlling depth of 39 feet. Several subsidiary channels, from 400 to 600 feet wide and 35 feet deep, serve marine terminals, waterfront industries, etc. Numerous anchorages are available with minimum depths of 30 feet. The total length of the developed waterfront of Baltimore Harbor, measured along the established bulkhead line, is in excess of 23

miles. The existing terminal facilities include; wharves, piers, grain elevators, coal and ore piers, storage and benkering for fuel oil, and terminal warehouses. The majority of deep draft foreign and domestic shipping is handled at terminals with depths of at least 35 feet alongisde. In addition, at Sparrows Point, the Bethelem Steel Company operates the largest tidewater ore dock in the world. This dock is 2,200 feet long, with an alongside depth of 40 feet, providing berthing space for three ore carriers up to 28,000 dwt each. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of the water alongside deepwater piers - 35 feet.
2. Controlling depth of channel - 39 feet.

Maximum size of tanker that can safely be accomodated:

32,000 dwt, representing 86% of the ocean - going tankers 2,000 dwt and over.

Alexandria, Virginia

There are no natural harbor entrance restrictions. The controlling depth of the channel is 20 to 25 feet. There are 5 commercial wharves, ranging from 150 to 200 feet in length. Depth of water alongside berths varies from 15 to 20 feet. Range of tide is 3 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of the channel - 20 to 25 feet.

2. Depth of water alongside piers - 15 to 20 feet.

Maximum size of tanker that can safely be accomodated:

4,000 dwt, representing 5% of the ocean-going tankers 2,000 dwt and over.

Hampton Roads, Virginia (including the Norfolk, South Norfolk, and Portsmouth Facilities)

There are no natural harbor entrance restrictions. Approach channels from the sea to the Hampton Roads complex are 1,000 feet wide, with a minimum depth of 40 feet. There are numerous deep-water anchorages available, with depths greater than 35 feet. There is ample maneuvering room for any class of vessel. There are numerous deepwater berths available, ranging in lengths from 200 to over 1,000 feet. Depths of water at these berths range from 30 to in excess of 40 feet. Range of the tide is 3 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of main channel - 40 feet.

2. Depth of water alongside piers - in excess of 40 feet.

Maximum size of tanker that can safely be accomodated:

50,000 dwt, representing 99.1% of the ocean-going tankers 2,000 dwt and over.

Richmond, Virginia

There are no natural harbor entrance restrictions. Richmond Deepwater Terminal is located 74 miles above the mouth of the James River. The channel has a minimum width of 200 feet, with a controlling depth of 25 feet. Anchorage areas extend up the James River about 7 miles from the mouth. The river commerce is handled at 14 privately owned wharves and 3 city owned wharves, with lengths up to 1,250 feet, and alongside depths of 25 feet. Several turning basins in the port area have been dredged to a depth of 25 feet. Range of the tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel and alongside piers - 25 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Wilmington, North Carolina

There are no natural harbor entrance restrictions. Wilmington is situated 25 miles above the mouth of the Cape Fear River. The channel has a depth of 35 feet over the ocean bar and thence 34 feet to Wilmington, thence 30 feet to and including a turning basin just above the mouth of the Northeast Cape Fear River opposite the seabord terminals. An anchorage basin is available at Wilmington,

with a depth of 34 feet. Several anchorages are also available in the Cape Fear River with a depth of 34 feet. There are numerous municipal and private piers ranging in length up to 1,500 feet, with depths alongside of 34 feet. Ample maneuvering room is available. Range of the tide is 3 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of channel leading to terminal facilities - 30 feet.

Maximum size of tankers that can safely be accomodated: 15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Charleston, South Carolina

There are no natural harbor entrance restrictions. The main ship channel from the sea to Charleston varies from 500 to 1,000 feet in width, with a depth of 34 to 35 feet. Numerous anchorages are available, with a depth of 34 feet. There is ample maneuvering room. There are 18 major berths available, with depths alongside ranging from 25 to 35 feet. The State Port Authority owns and operates the most modern terminal facilities south of Norfolk, Virginia. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of main channel - 34 feet.

2. Depth of water alongside piers - 25 to 35 feet.

Maximum size of tankers that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Savannah, Georgia

There are no natural harbor entrance restrictions. It is located about 20 miles up the Savannah River from the Atlantic Ocean. The river channel is approximately 500 feet wide with a controlling depth of 34 feet. Anchorages are available at the entrance to the river with depths ranging from 19 to 45 feet. Turning basins are provided in the port area. There are many wharves of all types, ranging in lengths up to 2,000 feet, with depths alongside up to 34 feet. Range of the tide is 7 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of the channel - 34 feet.

Maximum size of tankers that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Jacksonville, Florida

There are no natural harbor entrance restrictions. The main

ship channel has a controlling depth of 34 feet, with a minimum width of 600 feet. The harbor extends 8 miles along the St. Johns River, with terminal facilities on both banks. The municipal docks and terminals, owned and operated by the city, includes 3 finger piers, with deepwater berths averaging 30 feet alongside. In addition to numerous other terminals, 6 major oil companies maintain marine terminals for handling tankers. There are numerous anchorages available with depths ranging from 25 to 35 feet. There is ample room for maneuvering. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of the main channel - 34 feet.
2. Depth of water alongside piers - 30 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Palm Beach, Florida

There are no natural harbor entrance restrictions. Entrance channel is 200 to 300 feet wide with a minimum depth of 27 feet. A turning basin has been dredged to 25 feet. Except for actual emergencies, there are no anchorages available in the channel and turning basin. There are two slips available with more than 3,000 feet of berthing space and depths of 25 to 30 feet alongside. Adequate pipelines for the discharge of bulk petroleum products are available

in slip Number 2. Range of the tide is 2 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Restricted maneuverability due to narrow channel.

2. Controlling depth of channel - 27 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Port Everglades, Florida

Because of adverse current conditions, it is not advisable for vessels to navigate the entrance channel at night without a pilot. Anchorages are available south of the sea bouy in 60 feet of water. The entrance channel has a controlling depth of 35 feet, with turning basins dredged to the same depth. There is berthing space totaling 8,400 linear feet, ranging in individual lengths from 700 to 1,200 feet in length. All berths have 35 feet of water alongside. Range of the tide is 2 feet. Pilots and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel - 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Miami, Florida

There are no natural harbor entrance restrictions. The entrance to the main channel through the bay is an artificial cut 1,000 feet wide, dredged across the southern end of Miami Beach. The channel itself is 30 feet deep and 500 feet wide on the sea end, and 300 feet wide through the cut to Biscayne Bay. There are 3 connecting turning basins, situated along the Miami waterfront. Except for emergencies, there are no available anchorages for ocean-going vessels inside the harbor. The deepwater anchorages are outside the entrance, at an average depth of 30 feet. There are 3 piers, each in excess of 1,000 feet in length, with from 28 to 30 feet of water alongside. In addition, there is a causeway wharf 1,300 feet long, and a wharf operated by the Causeway Terminal, Inc., of 757 feet in length with controlling depths of 30 feet. Range of the tide is 2 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel and water alongside berths - 30 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

II. GULF COAST

Tampa, Florida

There are no natural harbor entrance restrictions. The main entrance channel has a depth of 34 feet over the bar, thence 32 feet to the harbor. Anchorages are available with depths up to 50 feet. There are 6 docks capable of handling several vessels at one time. Depths alongside range up to 32 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel - 32 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Port St. Joe, Florida

There are no natural harbor entrance restrictions. The entrance from the Gulf of Mexico is across shoals of about 18 feet in depth, through which a channel 300 feet wide and 37 feet deep has been dredged. Depth of the water in the harbor is 35 feet. There is ample anchoring room in depths of 37 feet. A large paper mill and an adjoining oil storage depot have a pier ½ mile in length, with alongside depths of 35 feet. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water in the harbor - 35 feet.

2. Depth of water alongside oil pier - 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Panama City, Florida

There are no natural harbor entrance restrictions. A channel has been dredged into St. Andrew's Bay from the Gulf of Mexico, with a depth of 34 feet in the approach and thence 32 feet to the deep water in the bay. Excellent anchorage can be found almost anywhere the depth is suitable. The usual anchorage for large vessels is in depths of from 35 to 40 feet of water. There are 4 main berths with depths of water alongside of 30 to 35 feet. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Channel depth of - 32 feet.

2. Depth of water alongside piers - 30 to 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Pensacola, Florida

There are no natural harbor entrance restrictions. The entrance channel from the Gulf of Mexico is 500 feet wide with a controlling depth of 32 feet. The average depth of water in the harbor is 32 feet. The 3 principle piers are all in excess of 1,000 feet in length, with minimum depths of 30 feet alongside. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depths alongside piers - 30 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Mobile, Alabama

There are no natural harbor entrance restrictions. Depth of water over the entrance bar is 38 feet. Main channel has a minimum width of 1,500 feet, with a controlling depth of 36 feet. Anchorages are available with depths of from 20 to 45 feet. The Port of Mobile has terminal facilities for 39 general cargo berths and 5 oil docks. Most piers and wharves, which extend along the bank of the West Mobile River, have depths of 26 to 35 feet alongside. Range of the tide is 2 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside piers - 26 to 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Gulfport, Mississippi

There are no natural harbor entrance restrictions. Gulfport is reached by a 12 mile channel from the Gulf of Mexico, with a minimum depth throughout of 32 feet. Good anchorages are available with depths of water up to 35 feet. There are several piers available ranging in length up to 2,000 feet. Depth of the water, in the harbor and alongside the piers, is 32 feet. Range of the tide is 2 feet. Pilots are compulsory and tugs are available, by special arrangement.

Principal limiting navigational factors:

1. Depth of channel, harbor, and alongside piers - 32 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

New Orleans, Louisianna

There are no natural harbor entrance restrictions. The port is situated approximately 100 miles above the Gulf of Mexico, on the Mississippi River. The two entrances to the river have controlling depths of 30 and 35 feet respectively. The river channel has a depth of 35 feet. Within the port limits, vessels may anchor only as direct-

ed by the Superintendent of Docks. Virtually all of the wharves are parallel to the river bank. There is an almost continuous quay for 10 miles along the bank of the river. Depths of water alongside the quay are from 30 to 60 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of channel - 35 feet.

Maximum size of tankers that can safely be handled:

Baton Rouge, Louisianna

There are no natural harbor entrance restrictions. Baton Rouge is situated about 120 miles above New Orleans on the Mississippi River. The. U.S.Corps of Engineers maintain a 35 foot minimum channel depth to Baton Rouge at all times. Except in cases of poor visibility or other emergency, anchoring is prohibited in the Mississippi River, outside of the several established anchorages. Depths of water in established anchorages are in excess of 40 feet. Facilities of the port include municipal docks and terminals, private docks, the facilities of an oil company, and an oil processing concern. Greatest depths of water alongside piers are 35 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of channel and alongside piers - 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Lake Charles, Louisianna

There are no natural harbor entrance restrictions. The port is located 32 miles from the Gulf of Mexico via the Calcasieu River and Pass Ship Channel. The main channel is 400 feet wide at the cut with a depth of 40 feet. Through the Calcasieu Lake, the channel has a minimum bottom width of 250 feet with a controlling depth of 35 feet. Large vessels usually anchor outside the bar entrance. No anchorages exist in the land cuts and ships are expected to complete any passage, after once entering such cuts. There are 4 main tanker wharves, with depths of 35 feet alongside. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of the lake channel and alongside tanker wharves - 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Port Arthur, Texas

There are no natural harbor entrance restrictions. Vessels enter through the Sabine Pass and proceed via the Port Arthur Ship Canal. The width of the main channel and canal is from 450 to 600 feet wide and has a minimum depth of 34 feet. Several anchorages are available with depths up to 36 feet. Several oil companies have facilities, with docking space ranging from 2,000 to 5,000 feet. Depths of water alongside range up to 38 feet. Turning basins with depths of 36 feet are available. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of the main channel and canal - 34 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of ocean-going tankers 2,000 dwt and over.

Neches River, Texas (Sub-Ports)

There are no natural harbor entrance restrictions. There are three major sub-ports on the Neches River between Port Arthur and Beaumont:

Atreco

A terminal owned and operated by the Atlantic Refining Company; it is located approximately 13 miles north of Port Arthur. This sub-port has 3 berths for seagoing tankers loaded to a draft of 34 feet.

Magpetco

A terminal owned and operated by the Mobil Oil Company; it is located approximately 11 miles below Beaumont. This sub-port has two medium sized berths or 1 super-tanker berth, capable of handling seagoing tankers loaded to a draft of 34 feet.

Smith's Bluff

A terminal owned and operated by the Pure Oil Company and a single berth tanker dock owned by the Sun Oil Company. The maximum length of berths is 1,100 feet. This sub-port is capable of handling seagoing tankers loaded to a draft of 34 feet.

The depth of the Neches River is 34 feet deep. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of the Neches River - 34 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of ocean-going tankers 2,000 dwt and over.

Beaumont, Texas

There are no natural harbor entrance restrictions. Beaumont is situated on the Neches River, 43 miles from the Gulf of Mexico. The entrance is through the Sabine Pass, thence by the

Neches Canal and River. There is a depth of 35 feet over the entrance bar, with a controlling depth of 34 feet in the main channel. There are no anchorages at Beaumont and anchoring is permitted in the Neches River only in emergencies. There are municipal wharves with a total berthing space of 3,750 feet. Depths of water alongside are 34 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of main channel - 34 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of ocean-going tankers 2,000 dwt and over.

Orange, Texas

There are no natural harbor entrance restrictions. The port is located on the Sabine River, 42 miles from the Gulf of Mexico. The main channel is from 125 to 200 feet in width, with a controlling depth of 30 feet. There are no anchorage areas in the vicinity of the port. Vessels may tie up to the banks of the river for limited periods, if permission is obtained from the Corps of Engineers. The Municipal Terminal, located on a slip 2 miles below the city, has a wharf 1,200 feet in length with 32 feet of water alongside. A turning basin 2,000 feet in diameter and 32 feet deep has been dredged in the port area. Pilots are compulsory

and tugs are available.

Principal limiting navigational factors:

1. Channel depth - 30 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of ocean-going tankers 2,000 dwt and over.

Galveston, Texas

There are no natural harbor entrance restrictions. There is a depth of 38 feet over the outer bar and 36 feet over the inner bar. The Galveston Channel has a minimum width of 1,200 feet, with a controlling depth of 32 feet. There are numerous anchorages available in Galveston Harbor, with depths of water ranging up to 41 feet. Most of the pier facilities are owned and operated by the Galveston Wharves Corporation. These properties include 32 piers and wharves with a total berthing space for 40 ships. Depths of water alongside piers range up to 35 feet. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of the Galveston Channel - 32 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of ocean-going tankers 2,000 dwt and over.

Texas City, Texas

There are no natural harbor entrance restrictions. The port is located 6 miles inland from the Gulf of Mexico, on Galveston Bay. The entrance channel has a minimum bottom width of 400 feet, with a controlling depth of 36 feet. The channel width in the port area is 1,000 feet. Anchorages are available with depths of 34 feet. There are 8 oil and chemical berths in the harbor, with depths alongside of 36 feet. Turning basins in the port have been dredged to channel depths. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel - 36 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Baytown, Texas

There are no natural harbor entrance restrictions. Baytown is the site of the Humble Oil Refineries and is the shipping port for their product. The main channel has a controlling depth of 34 feet. Anchorages are available with depths up to 35 feet. There are two concrete wharves, 400 and 600 feet long, with depths alongside of 32 feet. Ample maneuvering room is available. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside piers - 32 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Houston, Texas

There are no natural harbor entrance restrictions. The port is 22 miles above the head of Galveston Bay and 44 miles above the Galveston Entrance, with which it has deepwater connections through the Houston Ship Channel. The channel has a minimum bottom width of 300 feet, with a channel depth of 36 feet throughout. Anchorages are available in Galveston Bay, however vessels are prohibited from anchoring in the Houston Ship Channel except in cases of emergency. There is a turning basin in Houston, 1,100 feet in diameter. There are 17 public wharves ranging in length up to 826 feet. In addition to the public wharves, there are 40 private wharves ranging in length up to 2,600 feet. Depths of water alongside the piers range up to 36 feet. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of water in channel - 36 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Freeport, Texas

There are no natural harbor entrance restrictions. The main entrance channel has a controlling depth of 32 feet. There are several anchorages available with depths up to 32 feet. There are several oil piers with depths alongside of 30 feet. Turning basins are available, with depths of 32 feet. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depths alongside oil piers - 30 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Corpus Christi, Texas

There are no natural harbor entrance restrictions. The main ship channel is 250 feet wide with a channel depth of 34 feet. There are several anchorages available with depths of water of 34 feet. There are 9 oil piers with depths alongside of 34 feet. There are several truning basins, with depths of water of 34 feet, providing ample maneuvering room. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of channel and water alongside piers - 34 feet.

Maximum size of tankers that can safely be accomodated: 15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Port Isabel, Texas

There are no natural harbor entrance restrictions. There is 38 feet of water across the bar entrance, with a controlling depth in the main channel of 36 feet. Anchorages are available in depths of 35 feet. There is an oil loading dock for vessels up to 750 feet in length, with 35 feet of water alongside. Turning basins have been dredged to 36 feet. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside oil loading dock - 35 feet.

Maximum size of tankers that can safely be accomodated: 15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Brownsville, Texas

There are no natural harbor entrance restrictions. The port is connected with the Gulf of Mexico by a 17 mile long ship channel. The outer channel is 38 feet deep, with a 300 foot bottom width at the bar entrance. The main ship channel, 17 miles long, has a controlling depth of 32 feet with a 100 foot bottom width. There are several anchorages and turning basins available with

depths of 32 feet. There are 7 general cargo wharves ranging in length from 400 to 2,350 feet in length. In addition, there are 3 oil docks, with depths alongside from 30 to 35 feet, each of them 500 feet long. Range of the tide is 1 foot. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of the ship channel - 32 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

III. PACIFIC COAST

San Diego, California

There are no natural harbor entrance restrictions. The entrance channel is from 1,600 to 2,500 feet wide with depths of 36 to 70 feet for 5 miles, then 30 foot depths for an additional 4 miles. Ample maneuvering room is available, Both quay walls and piers are available, with lengths ranging from 400 to 4,600 feet in length. Depths alongside range from 18 to 36 feet. Range of the tide is 4 feet. Pilots are compulsory for overseas traffic and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside largest piers - 36 feet.

Maximum size tankers that can safely be accomodated:

32,000 dwt, representing 86% of ocean-going tankers 2,000 dwt and over.

Long Beach, California

There are no natural harbor entrance restrictions. Long Beach Channel has a controlling depth of 50 feet, with a middle width of 400 feet. Long Beach is composed of an inner, middle, and outer harbor. The outer harbor contains 6,500 acres of anchorage, with depths in excess of 30 feet. The middle harbor is enclosed by solid mole construction, with a 750 foot wide entrance channel, maintained at a minimum depth of 52 feet. There are 43

deepwater commercial berths, with a minimum depth alongside of 30 feet. The inner harbor has 47 berths with depths in excess of 30 feet. At present, 3 of the berths in the middle harbor are being redesigned to accomodate 105,000 dwt tankers. In addition, two 2,100 foot piers are under construction. Ample maneuvering room is provided. Range of the tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

None.

Maximum size of tankers that can safely be accomodated:

At present, the channel depth and berthing facilities are capable of effectively handling the largest of the super-sized tankers.

Los Angeles, California

There are no natural harbor entrance restrictions. Depth of water at the breakwater entrance is 48 feet. Outer harbor contains approximately 981 acres of anchorage with minimum depths of 35 feet. The inner harbor contains a water area of 804 acres, and consists of a series of channels 250 to 1,000 feet wide, with turning basins and numerous slips. The main channel is 1,000 feet wide and has a turning basin 1,600 feet in diameter. Controlling depths in the channels are 35 to 40 feet. A super-tanker terminal went into operation in July 1959. The approach channel to this terminal,

from the breakwater entrance, is 500 feet wide, 46 feet deep, and 1.75 miles long. The pier is reinforced concrete, 960 feet long, with outboard dolphins at either end to provide an overall tying-up length of 1,160 feet. Range of the tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

None.

Maximum size of tankers that can safely be accomodated:

At present, the channel depth and berthing facilities are capable of effectively handling the largest of the super-sized tankers.

Port San Luis, California

There are no natural harbor entrance restrictions. The entrance channel has a controlling depth of 30 to 35 feet. There is one fuel pier, 2,800 feet long with depths alongside of 33 feet. Range of the tide is 4 feet. Pilots and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of the channel - 30 to 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

San Francisco, California

There are no natural harbor entrance restrictions. The main ship channel has a width of 2,000 feet, with a controlling depth in excess of 40 feet. Numerous anchorages are available. Minimum anchorage depths are 30 feet. There is ample maneuvering room for all classes of ships. Total berthing space exclusive of pier ends, is 18 miles; with depths alongside ranging up to, and in excess of, 40 feet. Range of the tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

None.

Maximum size of tankers that can safely be accomodated:

At present, the channel depth and facilities are capable of handling effectively, the largest of the super-sized tankers.

Oakland, California

There are no natural harbor entrance restrictions. The port is situated on the mainland side of San Francisco Bay. The channel to all deepwater facilities is maintained at a depth of 35 feet. There are numerous anchorages available with minimum depths of 30 feet. The port contains a total of 13 miles of berthing space sufficient for 60 large deep draft vessels; with alongside depths ranging up to 35 feet. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of channel - 35 feet.

Maximum size of tankers that can safley be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Stockton, California

There are no natural harbor entrance restrictions. Stockton is located on the San Joaquin River, east of San Francisco. From San Francisco to Stockton, there is a limiting depth of 32 feet in the San Joaquin River. Dredged turning basins and anchorages are available, with a depth of 30 feet. There are 4 terminals available; oil, bulk-loading, and two for general cargos. Depths alongside range from 30 to 35 feet. Range of the tide is 3 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of San Joaquin River - 32 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Eureka, California

During certain tidal conditions, extremely strong currents are present over the Humboldt Bar, requiring ships to use extreme

caution. Controlling depth at the bar is 34 feet. Eureka is 6½ miles from the bar entrance, with a controlling depth in the channel of 30 feet and a width of 400 feet. Anchorages are available in depths of 25 to 30 feet. There is limited maneuvering room, due to the narrow channel. There are 8 principle docks in the Eureka-Humboldt Bay area, ranging in length from 375 feet to 1,500 feet, with an average alongside depth of 23 feet. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Dangerous sea conditions at the bar entrance.
2. Controlling depth of main channel - 30 feet.
3. Depth alongside piers - 23 feet.
4. Width of channel - 400 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Coos Bay, Oregon

Extreme caution should be exercised, when entering during periods of heavy weather, due to heavy surf conditions. During long runouts at ebb tide, currents up to 7 knots have been reported. Vessels are cautioned to be on the lookout for drifting logs. The limiting depth of the channel, from the harbor entrance to the Port of Coos Bay, is 25 to 30 feet. Anchorage can be had

almost anywhere in the bay, depending upon the draft. Maximum anchorages available are 36 feet. There is ample maneuvering room. There are 9 principle piers in the Coos Bay area, ranging in lengths from 200 to 1,345 feet in length, with depths alongside from 19 to 30 feet. Range of the tide is 6 feet. Pilots and tugs are available.

Principal limiting navigational factors:

1. During heavy weather extreme swells over entrance bar.
2. Depth of main channel - 25 to 30 feet.
3. Depth of water alongside longest pier - 30 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Astoria, Oregon

The Columbia River Bar is reported to be very dangerous due to sudden and unpredictable changes in the currents, often accompanied by heavy breakers. Currents at the entrance to the Columbia River have been reported as having exceeded 5 knots. Since logging is one of the main industries of the region, free floating logs are a constant source of danger. Controlling depth of the channel is from 30 to 35 feet. There is ample maneuvering room for ships of all classes. Anchorages with a controlling

depth of from 30 to 35 feet are available. The Port of Astoria operates a well equipped modern terminal of three piers, with an alongside depth ranging from 20 to 35 feet. Range of the tide is 7 feet. Pilots and tugs are available.

Principal limiting navigational factors:

1. Dangerous sea conditions at bar entrance.
2. Controlling depth of main channel - 30 to 35 feet.
3. Depths of water alongside piers - 20 to 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Portland, Oregon

The Columbia River Bar is reported to be very dangerous, due to sudden and unpredictable changes in the currents, often accompanied by heavy breakers. Currents at the entrance to the Columbia River have been reported as having exceeded 5 knots. Since logging is one of the main industries, free floating logs are a constant source of danger. Portland, on the Willamette River, about 9 miles from its mouth, is the principle city of the Columbia River Valley. Controlling depths of the channel are from 30 to 35 feet. Anchorages with depths of from 30 to 35 feet are available. There are 70 docks, within the 25 miles of the deepwater frontage on the banks of the river. Depths of water

alongside the deepwater piers range up to 40 feet. Range of the tide is 2 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Dangerous sea conditions at bar entrance.
2. Controlling depth of channel - 30 to 35 feet.

Maximum size of tankers that can safely be accomodated:

8,000 dwt, representing 8.4% of the ocean-going tankers 2,000 dwt and over.

Gray's Harbor, Washington

The entrance to Gray's Harbor is marked by lighted ranges and by bouys, which are shifted to mark the best water, as determined by frequent surveys of the bar. Deep draft vessels must wait for favorable bar conditions, before entering or leaving. The entrance channel is 800 feet wide, with a minimum depth of 30 feet. There is ample maneuvering room for all classes of ships. Suitable anchorages are available, with depths ranging from 35 to 40 feet. There are 27 quays and piers available with a total of almost 5,000 feet of berthing space available in the harbor complex. Depths alongside range from 22 to 35 feet. Range of the tide is 7 feet. Pilots should be considered compulsory and tugs are available.

Principal limiting navigational factors:

1. Adverse sea conditions at bar entrance.
2. Controlling depth of main channel - 30 feet.

3. Depth of water alongside piers - 25 to 35 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Port Angeles, Washington

There are no natural harbor entrance restrictions. Port Angeles is located on the Straits of Juan de Fuca. Depths of the channel and harbor range from 40 to 60 feet. There is ample anchorage available in depths in excess of 40 feet. There is one fuel pier available with a depth alongside of 35 feet. Range of the tide is 4 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside fuel pier - 35 feet.

Maximum size of tankers that can safely be accomodated:

32,000 dwt, representing 86% of the ocean-going tankers 2,000 dwt and over.

Anacortes, Washington

There are no natural harbor entrance restrictions. The controlling depth of the entrance channel is in excess of 40 feet, with a channel width of approximately one mile. Numerous anchorages are available, with water in excess of 30 feet; with an an-

chorage directly off the wharves, at the Port of Anacortes, in depths of from 36 to 72 feet. The port's commercial pier has a frontage of 440 feet, with a depth of 30 feet alongside. Range of the tide is 5 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Depth of water alongside pier - 30 feet.

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Everett, Washington

There are no natural harbor entrance restrictions. The main channel to Everett has a controlling depth of from 25 to 30 feet. The anchorage for the Port of Everett is close inshore, with a depth ranging from 30 to 90 feet. Ample maneuvering room is available. There are 9 deepwater piers, ranging in length from 400 to 900 feet, with alongside depths of from 12 to 38 feet. The range of the tide is 7 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

1. Controlling depth of Everett Channel - 25 to 30 feet.
2. Depth of water alongside piers - 12 to 38 feet. (Oil is delivered by barge to piers having about 12 feet of water alongside.)

Maximum size of tankers that can safely be accomodated:

15,000 dwt, representing 28% of the ocean-going tankers 2,000 dwt and over.

Seattle, Washington

There are no natural harbor entrance restrictions. The entrance from the sea is through the Straits of Juan de Fuca and the Puget Sound. Controlling depth of the channel is in excess of 40 feet. Numerous anchorages are available, with depths in excess of 40 feet. Ample maneuvering room is available to all classes of ships. Over 80 terminals are in use, with alongside depths ranging from 28 to over 40 feet. Range of the tide is 8 feet. Pilots are compulsory and tugs are available.

Principal limiting navigational factors:

None.

Maximum size of tankers that can safely be accomodated:

At present, channel depth and facilities are capable of effectively handling the largest of the super-sized tankers.

CHAPTER III.

SUMMARY AND CONCLUSIONS

Petroleum, Supply and Demand

Prior to World War II, the United States was both an important importer and exporter of oil. The principal reason for this was a matter of geography. It was more economical for oil from the West Coast to be exported to Asia, rather than through the Panama Canal to the oil-short northeastern part of the United States. The oil delivered to our eastern seaboard came primarily from the ports of the Gulf of Mexico and Venezuela. Oil from the Atlantic and Gulf ports of the United States was also exported to the needy markets of Europe.

During the period immediately following World War I, the world demand for both crude and refined petroleum totaled about $1\frac{1}{2}$ million barrels per day. Of this figure approximately 67 percent was consumed by the United States. By 1938, the world's demand had increased to $5\frac{1}{2}$ million barrels per day, with the U. S. consumption still in excess of 60%.

In 1947, the position of the United States was shifted from that of a net-exporter of petroleum to one of a net-importer. Since the World War II era, the emphasis has been on oil from the Far East rather than from the oil fields located on the Gulf of Mexico and the Caribbean Sea. This situation can be attributed to several de-

velopments:

1. The heavy demands on our domestic reserves made by World War II.
2. Domestic consumption of petroleum in the United States, during the post war period, has increased at an extremely rapid rate.
3. With an economy more dependent on petroleum than any other nation, and with the newly assumed post World War II, world-wide responsibilities, we must be in a position to meet not only our own needs, but must also be in a position to help satisfy the needs of the other friendly nations of the free world.

This is not to imply that we are facing an oil famine, but rather a diminishing return from our domestic resources.

Coupled with this heavy strain that had been placed on our crude petroleum, was the rapid rise in the proven oil resources of the Middle East. These reserves were estimated at 37% of the world's total in 1946. By the end of 1960, this figure had risen to 60% of the world's total. During this same period, crude oil production in the Middle East rose from 9% to 25% of the world's total.[1]

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[1] Alan C. Nelson and Preston P. Nibley, "Economics of Oil Transportation Middle East to Western Europe," World Petroleum, Vol. 32, No. 12 (Nov., 1961), 56.

By 1950, the demand for oil in the United States had reached a figure of $6\frac{1}{2}$ million barrels per day, which represented 64% of the world's total demand. The production of crude petroleum in the United States in 1950, was only 5.4 million barrels per day, representing 52% of the world's total production.

During the decade 1950-1960, the demand for petroleum in the United States rose at an average rate of approximately 5.5% annually, reaching a figure of 10.3 million barrels per day. The production of petroleum in the United States, by 1960, had reached 8.9 million barrels per day. The United States was now requiring approximately 59% of the free world's demand, however producing only 48% of the total production of the free world. By 1965, the demand rate in the United States is expected to reach 12 million barrels per day. (Table VII.)[2]

The projected demand for the entire free world, in 1965, is expected to reach 24.8 million barrels per day. It has been estimated that, to satisfy this demand, 12.3 million barrels per day, of both crude and refined petroleum, would have to be shipped by sea. Of this figure, 21% would be shipped from U. S. Ports. (Table VIII,)[3]

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[2] Harold Lubell, Middle East Crises and World Petroleum Movements, U. S. Air Force Project Rand, Research Memorandum 2185 (Santa Monica, California, 1958), pp. 23-25.

[3] Ibid., p. 25.

TABLE VII.

PETROLEUM DEMAND AND PRODUCTION IN MAJOR REGIONS OF THE FREE WORLD*

DEMAND:	1953		1959		1965	
	Thousands of Barrels Daily	Per Cent of Total	Thousands of Barrels Daily	Per Cent of Total	Thousands of Barrels Daily	Per Cent of Total
United States & Canada	8,148.5	66.1	10,250.9	59.6	11,988.0	51.5
Latin America	1,017.5	8.3	1,537.8	8.9	2,115.0	9.1
Western Europe	1,787.0	14.5	3,385.8	19.6	5,554.0	23.9
Middle East & Africa	621.0	5.0	911.0	5.3	1,270.0	5.5
Oceania, South & East Asia	754.0	6.1	1,145.5	6.6	2,316.0	10.0
Total Free World	12,328.0	100.0	17,204.1	100.0	23,244.0	100.0
PRODUCTION:						
United States & Canada	7,342.4	58.8	8,439.2	48.2	9,953.0	42.9
Latin America	2,278.0	18.2	3,564.4	20.3	4,600.0	19.8
Middle East	2,424.3	19.4	4,605.6	26.3	6,245.0	26.9
Africa & Western Europe	117.7	0.9	380.8	2.2	1,786.5	7.7
Far East & South Asia	330.9	2.7	529.7	3.0	622.2	2.7
Total Free World	12,493.3	100.0	17,519.7	100.0	23,206.5	100.0

*James S. Cross, "World Tankship Economics" (paper presented to a Session of the Annual Tanker Conference of the Central Committee on Transportation by Water and its Associated Committees of the Division of Transportation of the American Petroleum Institute at the Oyster Harbors Club, Cape Cod, June 12-14, 1961).

TABLE VIII.

MAJOR OCEAN MOVEMENTS OF CRUDE PETROLEUM AND REFINED PRODUCTS EXPECTED BY 1965 (THOUSANDS OF BARRELS DAILY)*

From: / To:	United States		Carib-bean	South America		West Europe		Africa		Middle East			Oceania	Communist Bloc	Total
	West Coast	Gulf Coast		West Coast	East Coast	North	South	North & West	South & East	Suez	Pipe Line	Indian Ocean			
United States															
East Coast	45.0	2,062.0	1,395.2		3.0	8.0		1.0		236.1	50.0				3,800.3
West Coast		30.0	20.0	3.0								113.4	45.0		211.4
Gulf Coast			45.0												45.0
Hawaii	15.0												35.0		50.0
Canada			388.2			2.0				113.5					503.7
Caribbean		44.0	179.0	3.0	30.0	17.0				12.0			23.0	90.0	398.0
South America															
East Coast		4.5	280.3		5.0	3.0						83.9	15.9		392.6
West Coast	6.0		44.7	3.6											54.3
West Europe															
North		46.0	572.3	4.2	5.8	502.5	58.3	449.0		1,918.9	545.8		53.8	110.0	4,266.6
South		4.0	25.0			25.7	40.1	854.0		442.3	327.5		7.2	90.0	1,815.8
Africa															
North & West			87.0			30.0	200.0	10.5	1.5	108.3		5.0		45.0	487.3
South & East		2.0	10.0			8.0		0.5	7.5			198.8	14.5		241.3
Middle East			7.0				17.0	0.6	0.7			211.5	2.0		238.8
South Asia	2.5		16.0			20.5	6.0		2.0			304.5	39.1	15.0	405.6
Indonesia, et al	3.0		6.0		2.0	5.0	5.0					90.2	196.5		307.7
Far East	60.0		4.0									984.5	100.0	40.0	1,188.5
Australia, et al	3.0		15.5	1.5		2.0						296.3	166.0		484.3
	134.5	2,192.5		15.3	45.8	623.7	326.4	1,315.6	11.7	2,831.1	923.3	2,288.1			
Total	2,327.0		3,095.2	61.1		950.1		1,327.3		6,042.5			698.0	390.0	14,891.2

*James S. Cross, "World Tankship Economics" (paper presented to a Session of the Annual Tanker Conference of the Central Committee on Transportation by Water and its Associated Committees of the Division of Transportation of the American Petroleum Institute at the Oyster Harbors Club, Cape Cod, June 12-14, 1961).

There appear to be three basic reasons for this rising trend in oil consumption, both here and abroad. The need for more electrical generating capacity and the demands of the transportation industry are, most probably, the two major factors. The third factor in the projected increase in petroleum demand is the steady increase in the use of petroleum derivatives.

There have been many noteworthy developments in the continuing search for wider fields of usefulness for petroleum. Over the past few years these developments have resulted in the introduction of literally hundreds of new commercial products and have expanded the fields of usefulness of others.

As a result of this rising demand for petroleum, the importing of crude and refined petroleum products into the United States has increased from 54.7 million barrels per year in 1935 to a figure of 646.5 million barrels per year in 1958. The exporting of crude and refined petroleum products during the same period of time only rose from 68.4 million barrels per year in 1935 to 73.8 million barrels per year in 1958. The major ocean movements of crude petroleum and refined products for the world during the year 1959 are shown in Table IX.

Tankship Economics

As previously mentioned, both to help meet the rising need for petroleum and to replace the World War II vintage tanker block, a continuing tanker construction program can be expected. The trend

TABLE IX

MAJOR OCEAN MOVEMENTS OF CRUDE PETROLEUM AND REFINED PRODUCTS IN 1959 (THOUSANDS OF BARRELS DAILY) *

From:	United States		Carib-bean	South America		West Europe		Africa		Middle East			Oceania	Communist Bloc	Total
To:	West Coast	Gulf Coast		West Coast	East Coast	North	South	North & West	South & East	Suez	Pipe Line	Indian Ocean			
United States															
East Coast	40.5	1,829.2	1,230.1		1.8	1.5	4.0	0.7		193.8	43.7				3,345.3
West Coast		27.4	17.1	1.9								99.1	68.7		214.2
Gulf Coast			34.0							12.6					46.6
Hawaii	31.8												0.2		32.0
Canada			270.3			0.8				104.7	0.6				376.4
Caribbean		40.3	237.0	0.4	23.2	13.7				9.5			20.6		344.7
South America															
East Coast		4.1	262.1		0.4	1.5						68.5	3.5	20.9	361.0
West Coast	3.9		22.5	5.7											32.1
West Europe															
North		43.2	550.5	3.0	4.2	289.8	33.9	28.2		1,368.7	375.0		48.4	104.6	2,849.5
South		18.1	24.5			15.0	23.2	42.7		413.8	411.4			93.7	1,042.4
Africa															
North & West		1.0	56.3			20.3	80.2	6.2	0.3	33.8	18.3	3.5		39.7	259.6
South & East		3.8	6.3			4.0	0.1	0.1	2.9			118.8	3.7		139.7
Middle East			5.3			0.7	9.4	0.3	0.5	8.9		143.4	1.9	10.2	180.6
South Asia	2.4		5.2			2.7	0.1		0.6			164.4	26.4		201.8
Indonesia, et al	1.5		4.2		0.4	1.3	2.7					64.2	123.0		197.3
Far East	54.6		2.1			0.2						361.2	72.1	2.6	492.8
Australia, et al	3.5		7.2	0.6		1.2						146.0	113.3		271.8
	138.2	1,967.1		11.6	30.0	352.7	153.6	78.2	4.3	2,145.8	849.0	1,169.1			
Total	2,105.3		2,734.7	41.6		506.3		82.5		4,163.9			481.8	271.7	10,387.8

*James S. Cross, "World Tankship Economics" (paper presented to a Session of the Annual Tanker Conference of the Central Committee on Transportation by Water and its Associated Committees of the Division of Transportation of the American Petroleum Institute at the Oyster Harbors Club, Cape Cod, June 12-14, 1961).

towards the increased size of tankers has a number of causes, however it appears obvious that the basic incentive is one of economy and increased operating efficiency.

The construction costs of a large tanker are approximately one-third less than the construction cost of two smaller tankers of the same aggregate tonnage. Shipyard costs for many construction operations are fixed, regardless of the physical size of the parts or equipment involved. Overall steel requirements are lower, and the prices of materials and equipment are basically the same, regardless of the size of any particular vessel. The duplication of equipment components would be unnecessary in the construction of only one vessel i.e., fathometer, radar, steering gear, etc. The reduced investment per unit of carrying capacity would result in lowered depreciation, interest, and insurance charges per unit of oil transported.

Engine size tends to increase less than proportionately to the carrying capacity in the construction of larger ships. The machinery for the efficient operation of a tanker in the 28,000 dwt class will cost approximately 30% less than the two units required in two ships of the same aggregate tonnage. Fuel consumption per unit of cargo transported decreases as the size of the ship increases, even though the larger, newer tankers generally are faster than the smaller class of ships they are replacing. Unit repair costs will likewise decrease. The size of the crew needed to operate tan-

kers increases in less proportion as the size and capacity of the ship is increased. Only 50 men are required to operate a 100,000 dwt tanker as opposed to the 41 men required on a 16,000 dwt T-2 type tanker.

The total of the reduced unit transportation cost resulting from the use of large tankers is shown as a percentage of T-2 operating costs in Table X. below.[4]

TABLE X.

UNIT COST OF TRANSPORTATION
RELATED TO TANKER SIZE

VESSEL SIZE (dwt)	RELATIVE UNIT COST OF TRANSPORTATION
16,000 (T-2)	100
19,000	90
30,000	63
45,000	51
70,000	43
85,000	40
100,000	38

If the present trend in the construction of tankers, well in excess of 30,000 dwt continues, and there is no reason to be-

[4]Loren F. Kahle and A. J. Kelly, "Development of the Modern Oil Tanker," Marine Engineering/Log, LXIV No. 8 (July 1959), 69.

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Table [illegible]

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lieve otherwise, it is readily apparent that the petroleum supply industry would rapidly make most of the ports of the United States obsolete.

Tanker Facilities

Before summarizing the present existing harbor facilities of the United States, it might be of interest to take a brief look at a few of the major harbor facilities of Europe and the Middle East. A paper published in WORLD PETROLEUM, November 1961, presented the following descriptive data:

> Deepwater terminals capable of berthing tankers up to 100,000 tons either have been completed or are planned at most of the major crude oil exporting centers in the Arabian Gulf. On many occasions the Kuwait Oil Company's giant terminal at Mina al Ahmadi has loaded tankers of the Universe Apollo (106,000 deadweight tons) and Universe Leader (85,000 deadweight tons) classes. The Arabian American Oil Company's terminal at Ras Tanura has handled tankers of the Universe Leader class regularly and can accomodate tankers of 100,000 tons. The Basrah Petroleum Company is currently building a sea island off Southern Iraq, which is designed to berth tankers of up to 100,000 tons. The Iranian Oil Participants commissioned in 1960 a new deepwater terminal at Kharg Island off Iran, which can accomodate 100,000 ton tankers. These terminals are being used by "giant" tankers carrying crude oil to deepwater terminals in consuming areas to the eastward as well as around the Cape to Europe and North and South America.
>
> Similarly, the pipeline terminals along the Eastern Mediterranean coast are capable of berthing tankers up to 85,000 deadweight tons. The Universe Leader has been loaded at Sidon, Lebanon, the terminus of the Trans-Arabian Pipe Line Company (Tapline). An improvement of the berth facilities has been planned to allow mooring tankers up to 100,000 tons on a regular basis. The Iraq Petroleum Company's terminal at Banias, Syria, presently can accomodate tankers up to 85,000 tons, and its terminal at Tripoli, Lebanon, is being improved to handle tankers of that size. In addition, Esso Standard (Libya), Inc. is installing a terminal at Marsa El Brega, Libya, which will be able to moor 100,000 ton tankers.

Development of deepwater tanker-unloading terminals at key locations in Western Europe is also progressing. Esso Petroleum and British Petroleum recently commissioned terminals at Milford Haven in the United Kingdom, which are capable of berthing tankers up to 100,000 tons. Shell Petroleum has completed a terminal for handling 65,000 ton tankers at Tranmere, United Kingdom. The new Esso refinery at Slagen, Norway, has a pier capable of berthing 100,000 ton tankers. Rotterdam and Wilhelmshaven, the terminals for the recently built crude oil pipelines into Western Germany, are being expanded and improved to handle 100,000 and 85,000 ton tankers, respectively, by 1965. The crude oil unloading terminal to be built at Lavera, France, for the South European Pipe Line will have a submarine berth capable of mooring 85,000 ton tankers.

The widespread development in the Middle East and Western Europe of oil terminals for accomodating tankers in the 65,000-100,000 ton range provides physical evidence of the economic attractiveness of these larger vessels.[5]

A survey of the oil ports of the United States was given in Chapter II. The results as to the maximum size of tankers that can presently be safely accomodated have been summarized in Table XI. From this table, it is noted that only 30.4% of the present United States oil ports are capable of handling tanker sizes up to 32,000 dwt, and only 10% are capable of handling tankers up to a size of 50,000 dwt. As indicated by Table II. in Chapter I., the total number of tankers in the world's fleet in excess of 30,000 dwt stands at 576. Of the tankers under construction or contracted for as of July 1, 1961, 75.7% are in excess of 30,000 dwt. (Table IV., Chapter I.)

Of the five U. S. ports presently capable of handling super-

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[5]Nelson and Nibley, op. cit., 58.

TABLE XI.

MAXIMUM SIZE OCEAN-GOING TANKERS CAPABLE OF BEING SAFELY ACCOMODATED IN U. S. OIL PORTS (69 PORTS SURVEYED)

MAXIMUM SIZE TANKER	NUMBER OF PORTS	CUMULATIVE PERCENTAGE
4,000 dwt	69	100.0%
8,000 dwt	68	98.5
15,000 dwt	52	75.4
32,000 dwt	21	30.4
50,000 dwt	7	10.1
over 50,000 dwt	5	7.2

tankers up to the 100,000 dwt class, only one is on the East Coast, with the remaining four on the West Coast. Of the three located in California, two, Long Beach and Los Angeles, can be considered to be one and the same port. While each of these ports is capable of handling vessels up to the 100,000 dwt category, their facilities are taxed to the utmost. It is doubtful that they will be able to handle the three 130,000 dwt tankers currently under construction. With a safety factor of five feet, none of the ports serving the oil fields bordering on the Gulf of Mexico are capable of handling tankers of 30,000 dwt.

This is not meant to imply that these five super-tanker ports are the only ones having a high percentage of petroleum traffic. Table XII. has been included to show the petroleum traffic, as a percent of the total shipping handled, in each of the major U. S. oil ports during the year 1958.

Alternatives

The author believes that there are three major alternatives to the solution of the inadequate capacity problem, of the great majority of the oil ports, of the United States.

The obvious first alternative is to do nothing, that is, make no harbor improvements. The impact of this alternative on the importing and exporting of petroleum in the United States would be that:

TABLE XII.

PETROLEUM TRAFFIC AT MAJOR U. S. PORTS*

PORTS	PETROLEUM TRAFFIC AS A PERCENT OF TOTAL PORT TRAFFIC
Boston	70%
Providence	86
New York	61
Philadelphia	53
Baltimore	26
Savannah	50
Mobile	23
New Orleans & Baton Rouge	58
Galveston & Houston	59
San Diego	75
Los Angeles & Long Beach	76
San Francisco	72
Seattle	45

*Petroleum Facts and Figures, 1959, New York, American Petroleum Institute, 189.

1. Only relatively small-sized tankers would be capable of effectively utilizing the majority of the U. S. oil ports.
2. Super-sized tankers calling at the majority of U. S. oil ports would be forced to arrive or depart with a limited load, conditioned by the principal limiting navigational factors of the port concerned.
3. Super-tankers in a fully loaded condition, arriving at a U. S. port with a draft in excess of the controlling depth of the entrance channel, or the water alongside the oil berths, would have to rendezvous with smaller size tankers to effect a transfer of enough cargo to reduce the super-tanker's draft to allow safe entrance into the port. For super-tankers proceeding to sea, the reverse process would be necessary.

The major disadvantage of this alternative would be the higher unit transportation costs involved, for both imports and exports. These higher costs would be a result of using several small tankers instead of one super-tanker, using super-tankers in a partially loaded condition, or the need of several small tankers for super-tanker offloading purposes.

In terms of national defense, the oil terminal facilities of the United States would continue to be widely dispersed as they

are at present. However, during periods of national emergency, an extremely large number of relatively small-sized tankers would be required, to meet the expanded demand for petroleum products, that would result both internally and abroad.

The second alternative would be one of a major program of channel and harbor dredging, together with terminal improvements or construction, at either preselected ports or in all of the oil ports of the United States. In addition to extensive dredging operations, super-tanker terminals would require elaborate fendering systems to absorb both, forces transmitted by ships to their respective berthing structures, and resulting forces on the ships' hulls. They would also require greater attention to the methods of securing lines to the piers. The extent of internal harbor development could be lessened by the construction of terminals in deeper waters, with direct channel approaches from the sea. This however, would normally require such terminals to be located where natural shelter from the wind, sea, and swell would be considerably less than favorable.

The major disadvantages of this alternative are the lack of current funds and the time lag required for both the approval of such funds and the actual development operations. Because the benefits from the improvement and maintenance of channels are general in nature and provide economic stimuli to the entire economy, the project is a Federal responsibility. The U. S. Army Corps of

Engineers, as a Federal agency, has been charged with this responsibility.

Due to our national procedure for the justification, authorization and procurement of funds for channel improvements, the projects generally lag many years behind their need. Under this procedure, local interests desiring navigational or harbor improvements must have a resolution introduced in Congress, which authorizes the Corps of Engineers to hold a public hearing. At these hearings, interested parties are offered the opportunity to submit their recommendations. If the proposed project is justifiable, the Corps then has to acquire the necessary funds required to make a detailed study. If this study, conducted by a District Engineer, finds the project to be warranted and economically justified, recommendations are forwarded to the Division Engineer. From the Division level, the recommendation then must proceed to the Chief of Engineers, in Washington, and the Board of Engineers for Rivers and Harbors. Approval must also be obtained from the Governors of the states involved and from the Bureau of the Budget. If the project is still approved at this time, the project is referred to the Congress for inclusion in a River and Harbors Bill, which places it in line for a Congressional authorization. Following authorization, there is still the problem of the appropriation of the necessary funds to commence the actual construction. For major projects, the time lag from the initial recommendations to the appropriations of funds, plus the actual construction time, can easily total up to from five

to ten years.

The third course of action is one which I feel offers the best solution to the problem in this paper. This would be the establishing of deepwater super-tanker sanctuaries. A terminal buoy system would be located in these areas. Such a system, using the IMODCO buoy, was demonstrated by the Royal Swedish Navy in July 1959. The buoy was named for its designer and manufacturer, the AB International Marine & Oil Development Corporation of Stockholm, Sweden.

The IMODCO buoy is of a large circular design, very much like that of a standard mooring buoy. The buoy is available in several sizes ranging from 9.8 to 41 feet in diameter. The attached ground tackle is of such a size and so placed, as to hold ships of predetermined weight characteristics effectively. Ships moored to a specially designed hook, mounted on a swivel, are permitted a full 360 degrees swing. Flexible hoses leading to the buoy are coupled directly to a tanker's cargo piping, and loading or discharge is carried out through submarine pipelines. The terminal site can be shifted as the need arises without abandoning expensive terminal installations. Due to the mooring arrangement, ships would be capable of effecting a moor in winds of higher velocity, than would be practicable at other types of terminals. Once moored, vessels are free to ride to the wind or sea, without any undue side stresses on the ground tackle.

The present offshore terminals, now in use, require a tanker to moor in a fixed position with no swing allowed. This type of terminal has had a limited degree of success in some ports of the United States. However, this type of moor has some disadvantages, which are overcome by the IMODCO buoy system.

The biggest advantage of the IMODCO system, is the ability of tankers to moor and to ride out rough weather while moored, and to continue to load or unload during adverse weather conditions. Some of the other advantages of this type of system are:

1. Lessens the danger of harbor pollution by oil.
2. Oil tank storages can be located in areas remote from population centers.
3. Reduces the risk of collision for large super-tankers in crowded harbors.
4. Reduces pilot and tug costs.
5. Reduces fire and disaster hazards in populated areas.
6. Eliminates high cost of dredging operations in ports presently incapable of handling super-tankers.
7. Where a suitable number of buoys are provided, vessel waiting time for loading or discharging facilities is reduced.
8. Can release existing oil berths for other commercial usage.
9. Initial costs are far less than that of harbor terminals and, operating expenses are less.

It appears reasonable to assume, that the use of a system similar to the IMODCO buoy terminal, would solve the problems that would result from the adoption of either of the first two alternatives. Sanctuaries could be located in deepwater areas close to oil producing areas and refineries. With their location in deepwater areas, there would be no restrictions placed on the usage of super-tankers. It would be a relatively easy matter to determine the number of buoys required to reduce tanker waiting time to a minimum figure. From both National and Civil Defense aspects, the resulting dispersal of oil terminals from each other, and from the immediate vicinity of highly populated areas, would seem to make this type of system highly desirable. With the use of prefabricated storage tanks and semi-portable pipelines, such as used by the U. S. Navy to deliver petroleum products ashore during amphibious operations, this type of system could, if necessary, prove to be highly portable.

Conclusions

Since the birth of the United States as a Nation, we have been among the maritime leaders of the world. Our harbors and facilities have been the envy of others. The United States Merchant Marine, both ships and crews, has been and still is, one of the best in the world. How long will these conditions last? How long will the United States be in a position to boast, if it continues to drag its heels in providing terminal facilities capable of effectively handling the large commercial vessels of today and tomorrow?

Our harbors and their facilities are extremely complex in their make-up. Petroleum traffic is only one part of the total, however the petroleum industry has a vital place in the economy of our nation. If the heavy petroleum traffic is restricted or sharply reduced, due to the inadequacy of our oil terminals, adverse effects will be felt throughout the nation.

Improved terminal facilities will quite obviously foster; national defense benefits, the expansion of existing and the development of new industrial production, through improved transportation, and the safety and convenience of all navigation. If we are to compete in international trade, we must provide harbor and terminal facilities to accomodate super-sized ships.

Up to the present time, one of the major drawbacks to the solution of harbor development is an excessive time lag. On the surface, it might appear that this lag is a direct result of the apparent slowness of our national government to take action, where action is needed. However, the solution to the problem cannot be resolved by Congress alone. The answer must be found in the close cooperation of both the petroleum supply industry and the Government of the United States. The answer to the problem must be based on the effects of petroleum related to; our national economy, the position that the United States seeks to attain and hold as a leader in world trade, and our national defense goals.

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