The Evolution and Prospects of the Post-OPA90 Alaskan Oil Trade

by

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B.S., Naval Architecture and Marine Engineering (2004)

Webb Institute

Submitted to the Department of Ocean Engineering
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Ocean Systems Management

at the

Massachusetts Institute of Technology

June 2005

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ACKNOWLEDGEMENTS

The author would like to thank Dr. Henry S. Marcus, Professor of Marine Systems at the Massachusetts Institute of Technology, for his valuable help and advice in the research, creation, and preparation of this thesis.

Thanks are also extended to the faculty of Webb Institute for additional guidance provided in the development of this thesis.

ABSTRACT

In response to the grounding of the Exxon Valdez on March 24, 1989, the United States Congress enacted the Oil Pollution Act of 1990, a series of regulations requiring technical and operational changes in tank vessels trading in U.S. waters with the intention of preventing future spills. Although the effects of OPA90 have been felt worldwide, vessels serving the Trans-Alaska Pipeline System have been particularly affected by the legislation. Trading between Valdez, Alaska and West Coast U.S. ports the TAPS trade is one of the few routes actively plied by Jones Act vessels. The age and design of the vessels engaged in the trade will require that many be phased out in accordance with OPA90 regulations in the coming years. Fleet capacity accounting for mandatory vessel phase outs is analyzed with respect to various crude production estimates for years 2000 to 2020. Potential design changes that may extend these vessels' trading lives are discussed. Shipyard capacity and factors affecting construction of ships in American yards are reported as well as the status of U.S. government programs designed to support the U.S.-flag fleet. Additionally, the potential impact that construction of ten 46,000 DWT product tankers may have on trade capacity is considered. The schedule at which these vessels must be delivered in order to meet Alaskan production estimates through 2039 is analyzed.

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INTRODUCTION

In a February 2004 report entitled Alaska's Oil and Gas Future: New Frontiers, Expanding Opportunities, Mark D. Myers, director of the State of Alaska's Department of Natural Resources, Division of Oil and Gas, outlined the importance of Alaskan oil to the United States economy:

- 22% of total U.S. oil reserves
- 7.1 billion barrels of oil
- 19% of total U.S. gas reserves
- 36.2 trillion cubic feet of gas
- 19% of total U.S. oil production
- 0.993 million barrels of oil per day
- Total Alaskan production to date:
    - 15.3 billion barrels of oil
    - 7.0 trillion cubic feet gas (net production)

The value of Alaskan oil to the whole United States is clearly very great; however, the cost for obtaining these resources can also be high. The ecology of Alaska has always been at the forefront of the debate over production in the region, and the grounding of the tanker *Exxon Valdez* in March 1989 became a call for reform in the oil transport industry. Recent initiatives to open the Alaskan National Wildlife Reserve to drilling have again caused focus to shift on the valuation of Alaskan oil production to the U.S. and world economies.

TRADE HISTORY

The presence of oil at Prudhoe Bay field was confirmed by Atlantic Richfield Company and Humble Oil in 1968. Early experiments in transporting oil directly from North Slope production centers utilizing the ice-strengthened tanker *Manhattan* were disappointing. After several years of planning and environmental impact studies, Presidential approval for the construction of a trans-state pipeline connecting the Prudhoe Bay field with Valdez, Alaska, was garnered in 1973. This structure was critical to make production viable, as it was necessary to link the production site with an ice-free terminal for transshipment to markets. The Trans-Alaska Pipeline System (TAPS) began operations on June 20, 1977, and the first shipment of oil left the Valdez terminal aboard the tanker *ARCO Juneau* on August 1, 1977.

Although the presence of Alaskan oil was confirmed in 1968, the Arab Oil Embargo of 1973 served as a strong catalyst for congressional approval of its production. The Trans-Alaska Pipeline Authorization Act of 1973 required that the oil be for domestic use only, banning exports to potentially lucrative markets in Asia. Controlled U.S. domestic prices had led to production demand that could not be satisfied, and steadily increasing world oil demand had led to world oil prices twice that of U.S. regulated prices by 1974. Production of the crude reserves at Prudhoe Bay represented the simplest solution to this imbalance- a readily available source of crude that would provide the highest present value on wellhead prices to producers. Although a variety of routes for transporting the oil out of Prudhoe Bay were considered, many stakeholders had to be satisfied before the project could move forward. The maritime industry, in particular, was active in pressing for domestic production of these reserves, arguing that

banning the exportation of this oil would "enhance national security, create jobs, and reduce reliance on foreign oil (Cato 1)."

The system design that created the TAPS tanker trade based out of Valdez was only one of several production strategies considered for use in transporting Prudhoe Bay crude. As discussed in *Alaskan Oil: Alternative Routes and Markets*, an all-land pipeline through Canada (known as the Mackenzie Valley route) terminating in the American Midwest was also considered. This route was significantly longer and more difficult to construct than the Valdez route, though it had the advantage of providing the Midwest with a steady source of oil and creating a major terminal at a centralized location for distribution to the rest of the country through other pipelines. Environmental and economic conditions eventually led to the construction of the Valdez route. However, in its *Final Impact Statement* Cicchetti states that the U.S. Department of the Interior concluded that from the standpoint of risk or threatened environmental impact the trans-Canada route was superior to the TAPS route for both the terrestrial and marine environments (56).

TAPS Network

Central to any production decisions regarding Alaskan oil is the capability of the Jones Act fleet to transport North Slope crude to markets in the contiguous states. The geography of Alaska is such that in order to be marketable oil must be transferred from production fields in the north of the state to tank vessels at the port of Valdez on the southern coast by way of the Trans-Alaskan Pipeline System, as shown in Figure 1.

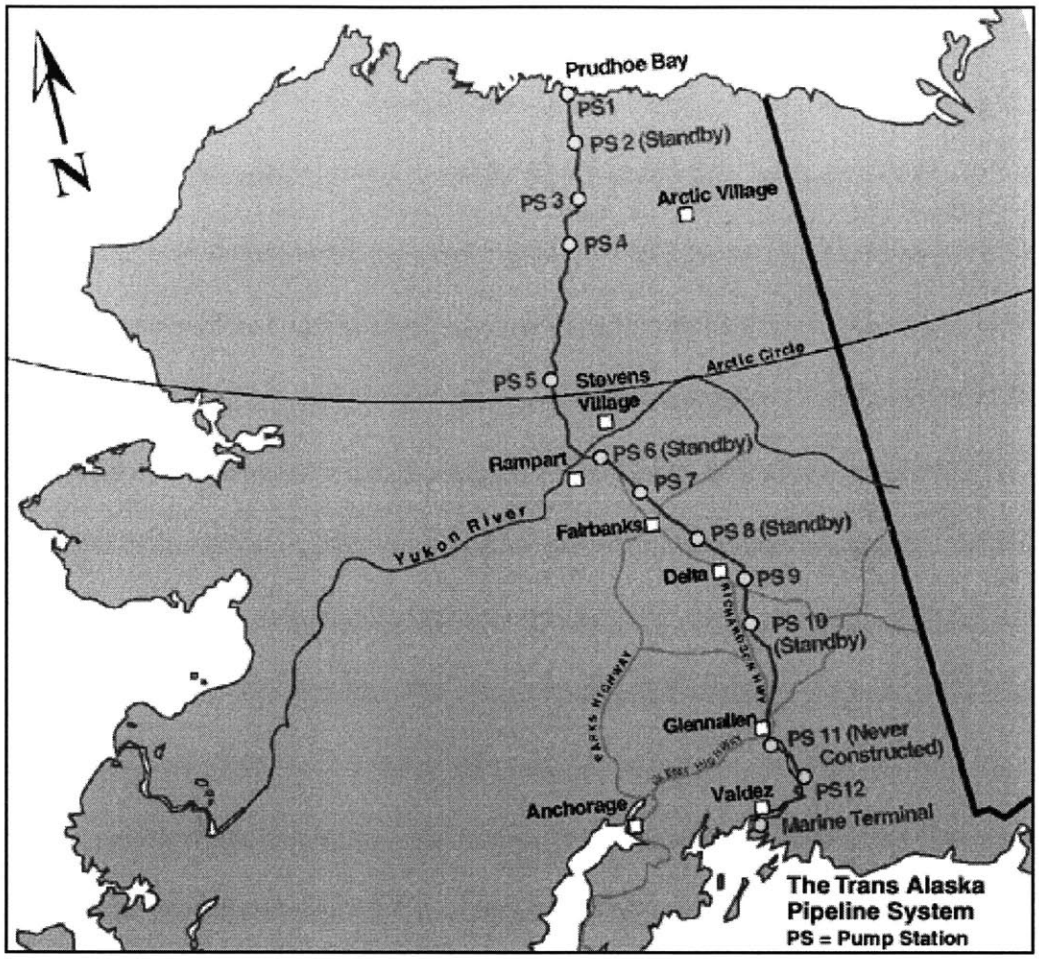

Figure 1: The route of the Trans-Alaska Pipeline (Solcom House 1)

The cost of the TAPS pipeline was $8 billion at the time of construction. The pipeline was designed to have an average maximum throughput of 2.136 billion bbl/day, although by 2000 the transfer rate had decreased to 0.99 billion bbl/day. The marine terminal built at Valdez covered 1,000 acres and contained holding tanks for 9.18 million bbl of crude. One floating and three fixed-platform berths for tankers were constructed, with the fixed platforms having a loading capacity of 100,000 bbl/hr and the floating berth 80,000 bbl/hr. Facilities for vapor recovery and ballast water treatment were included.

Vessel Utilization

Early TAPS vessels were drawn from a variety of US tanker routes active in the 1970's. At that time domestic oil and product movements, as well as international movements aboard Jones Act vessels, were at significantly higher levels than at present. 1976 (historic, pre-TAPS) and 2002 (modern, post-OPA90) domestic seaborne chemical and petroleum movements (excluding barge shipments) are illustrated in Table 1.

Voyage	1976 (MM LT)	2002 (thousands t)
USNH-USNH	15037	911
USG-USNH	39116	3806
USG-USSH	17	11048
USG-USG	6807	9181
AK-Pacific	7112	46248

Table 1: Domestic seaborne chemical and petroleum movements, 1976 and 2002. (Source: du Moulin 175, MARAD U.S. Domestic Ocean Trades 9)

Significant changes in the nature of domestic seaborne liquid trade can be seen by the figures in Table 1. Shipments to the North of Hatteras region have significantly decreased since 1976. This is due both to the prevalence of other transportation systems (pipelines and barge movements) as well as fundamental shifts in industry. The South of Hatteras and Gulf regions have experienced less change. The development of the TAPS trade has significantly impacted West Coast shipments. This impact, however, is limited to the West Coast itself; shipments from Alaska to regions other than the West Coast or the West Coast to other domestic regions onboard ships are insignificant.

EVOLUTION OF TRADE

As the Alaskan oil market developed and reached maturity, its role in serving U.S. energy needs changed as well. Although the oil embargoes of 1973 and 1978 did illustrate vulnerabilities in the American dependency on imported oil, the TAPS project

was never intended to eliminate this dependency. In fact, U.S. dependency on foreign oil has steadily increased since the opening of the TAPS trade. Debate over the trade has continued as its role in the U.S. energy market has become less clear.

Significant attention has been focused on the TAPS trade since the grounding of the Exxon Valdez in Prince William Sound in 1989. The development and passage of the Oil Pollution Act of 1990 (OPA90) has had significant implications on tanker fleets worldwide. Domestic tankers have been most acutely affected due to their age and trading needs. Fleet renewal is highly debated but mandates for technological change are unavoidable. The future of Alaskan oil production itself is in question, particularly plans to open vast expanses of the Alaskan National Wildlife Refuge to drilling.

Changes to TAPS Network

Key to passage of any congressional act authorizing the development of the Alaskan oil trade was the provision that Alaskan oil products would be produced for domestic markets. Although Asia would be the natural market for Alaskan crude, based both on geography and demand for the specific quality of crude, fears that oil companies would attempt to sell crude on more profitable international markets were addressed in the legislation authorizing the development of the TAPS network. Maritime unions, recognizing the effect that this would have on the dwindling U.S.-flagged tanker fleet, were especially keen on this provision. The Merchant Marine Act of 1920, generally referred to as the Jones Act, stipulated that cabotage trades be carried by American built, crewed, and owned vessels. Shipment of Alaskan crude internationally was explicitly banned in the 1973 Act and subsequent bills strengthened this position including the Energy Policy and Conservation Act of 1975, the Naval Petroleum Reserves Production

Act of 1976, the 1978 amendments to the Outer Continental Shelf Lands Act, and the 1977 and 1979 amendments to the Export Administration Acts.

Opposition to banning exports of Alaskan crude have been raised since the initiation of TAPS service, initially from oil refiners interested in serving international markets where oil prices were higher but subsequently from economists and consumer watchdogs. Although Alaskan crude is of higher quality than California and other domestic crude, its chemical impact is not great enough on refinery processes to offset the characteristics of heavy blends processed at the same plants. Consequently, one quarter of refined product is residual oils, not marketable in the region for the power production or chemical trades that create most of the American market. Most is then sold off as bunker fuel at a discount or shipped as 'product' (not crude) to the Far East. Although some decrease in dependence on foreign sources in the regions near refineries has resulted, this has been offset by growing demand and the necessity of importing gasoline additives to make local blends suitable for consumer use.

Economists have been interested in the impact that required domestic refinement of Alaskan crude has had on fuel prices. Van Vactor reports that the export ban "has depressed Alaska and California crude oil prices by an average of $1 to $5 per barrel" which significantly impacts revenues and resource values (1). Distorted market prices have the effect of artificially altering true supply and demand levels which, if restored to 'real' values, could significantly and adversely alter market composition.

Excess supply of crude and changes in world oil prices led Congress to enact legislation in 1995 permitting exports of limited quantities of Alaskan crude. At that time Alaskan production had exceeded West Coast refinery capacity, leading to about 300,000

bbl per day to be transshipped to the U.S. Gulf Coast via the Panama Canal. Although a short-lived boon for the Jones Act tanker fleet, the inefficiency of the situation was too severe to continue.

Since 1995 about 7% of Alaskan annual crude production has been earmarked for shipment abroad, mostly to Korea (50%), Japan (36%), and China (12%). This exported crude is equal to less than 0.5% of the total domestic consumption of 19.3 million barrels per day. Exportation of refined products to the Far East has also continued, principally petroleum coke used in steel making. Most product exports, however, have been directly to refineries in Canada and Mexico.

Changes in Vessels

The steady decline of many domestic trades and competition from foreign-flagged vessels on international routes created little demand for Jones Act tonnage. The TAPS trade, therefore, was able to absorb many Jones Act vessels squeezed out of other trades. No significant new tanker construction programs resulted immediately from the opening of the Alaskan oil trade; and most vessels that found their way into TAPS service were not designed explicitly for the route.

Steady growth in vessel sizes characterized post-WWII tanker construction. Vessel buildings per year and general vessel sizes can be seen in Appendix A. A summary of the current TAPS fleet is given in Table 2 and Appendix A.

Tanker Name	Build Date	Hull Configuration
KENAI	1979	Double Hull
DENALI	1978	Double Bottom
**MARINE COLUMBIA (ex OMI COLUMBIA)	1974, 1983	Single Hull
OVERSEAS CHICAGO	1977	Double Bottom
OVERSEAS NEW YORK	1977	Double Bottom

OVERSEAS WASHINGTON	1978	Double Bottom
PRINCE WILLIAM SOUND	1975	Double Hull
TONSINA	1978	Double Hull
ALASKAN FRONTIER	2004	Double Hull
ALASKAN EXPLORER (delivery 02/2005)	2005	Double Hull
ALASKAN NAVIGATOR (steel has been cut)	2006	Double Hull
ALASKAN LEGEND (scheduled newbuild)	2007	Double Hull
POLAR ALASKA	1979	Double Bottom
POLAR CALIFORNIA	1980	Double Bottom
POLAR ENDEAVOR	2001	Double Hull
POLAR RESOLUTION	2002	Double Hull
POLAR DISCOVERY	2003	Double Hull
POLAR ADVENTURE (in TAPS 01/2005)	2004	Double Hull
POLAR ENTERPRISE (under construction)	2005	Double Hull
**SEARIVER BAYTOWN	1984	Double Bottom
SEARIVER COLUMBIA BAY (ex BT ALASKA)	1978	Double Bottom
SEARIVER HITCHINBROOK (ex OVERSEAS OHIO)	1977	Double Bottom
SEARIVER LONG BEACH	1987	Single Hull
**SEABULK ARCTIC (ex CAPE LOOKOUT SHOALS)	1998	Double Hull
**SEABULK PRIDE (ex NANTUCKET SHOALS)	1998	Double Hull

Table 2: Jones Act vessels currently engaged in TAPS trade. ** Indicates product carrier currently being used for crude transport. (Source Maritime Business Strategies)

Vessel Valuation and Ownership

By 1990 the U.S. coastal tanker industry consisted of 147 vessels operated by 28 companies, including major and independent oil companies as well as independent tanker operators. Vessel ownership was very scattered, with each operator generally controlling one or two vessels. The two largest companies together controlled less than 20% of the domestic fleet. This market profile was a trend reflected in the international tanker market at the time. The 1970s had been a decade where oil majors had significantly expanded their fleets, but market volatility, specifically the embargoes of 1974 and 1979, led to fleet dispersal among many small operators. Oil majors controlled 20% of all

tankers in 1991, down from about 33% in 1968. Low freight rates in the early 1980s led to fewer time charters. Fleet buildup by independents for trade on the spot market characterized the market of the late 1980s (Lamb and Bovet 153).

EFFECTS OF OPA90 ON THE ALASKAN OIL TRADE

The passage of the Oil Pollution Act of 1990 by the United States government has impacted shipping worldwide as no other national law has. U.S. markets account for approximately 30% of world seaborne oil movements, making it difficult for any operator to avoid this market over the life of a vessel (Lamb and Bovet 151). Although originally focused on protecting Prince William Sound, Puget Sound, and other environmentally sensitive areas frequented by tanker traffic, significant implications in terms of vessel liability, operations, and strategic design have emerged from this legislation.

ORIGINS AND IMPLEMENTATION OF OPA90 LEGISLATION

Annually some 6,000 oil spills occur in U.S. waters. Less than 0.3% of spills exceed 50,000 gallons in size. The grounding of the Exxon Valdez on March 24, 1989, through a unique combination of environmental concern, media, and politics, became the catalyst for significant reform in tanker design and operations. Some 258,000 barrels of oil were lost from the Exxon Valdez (Bartel 92). Although by no means the largest spill in history, the incident caused the industry and national governments to scrutinize how safety and environmental legislation had failed and what needed to be done to prevent a similar crisis in the future.

The origins of OPA90 can be traced back many years prior to the grounding of the Exxon Valdez. Fears by tanker owners that overregulation by the IMO was affecting operation had led the trade organization INTERTANKO to promote passage of resolution A.500 in 1981, which resolved that new regulations for shipping should only be implemented when a need for such regulations was pressing and that efforts should be

made to encourage the ratification of IMO resolutions by national governments (Papachristidis 5). At this time the MARPOL convention had only been ratified on a limited basis, and environmental safety and anti-pollution standards were lax. Tonnage admeasurement for vessels with double skins or segregated ballast tanks was not in effect, exacting a financial penalty by many environmentally conscious operators (Papachristidis 6).

Spill prevention and liability were not concepts that were being ignored by vessel operators, and INTERTANKO and other trade organizations were making serious attempts to prepare themselves for a serious spill in the months prior to the Valdez grounding. The IMO was attempting to pass a revised version of the 1984 Protocols in 1987 and 1988, a convention which would increase spill compensation payments. However, ratification was the difficulty, particularly by the United States (Papachristidis 8). A bill was introduced that would not only ratify the convention but pre-empt states' rights to pass or maintain legislation conflicting with the convention. In effect, passage of the bill would have shifted authority in determining spill liability from U.S. or state governments to the IMO. Before the bill could be passed, however, the Exxon Valdez touched bottom.

Calls for a direct, domestic response to the Exxon Valdez grounding came from many fronts including environmental watchdogs, fisheries, and other public interest groups. Senator George Mitchell (D-ME), who had opposed ratification of the IMO convention, now sought to pass legislation that would not only authorize federal legislation related to oil pollution but permit states to add their own provisions to the federal law (Suzuki 2). Environmental groups, who had lobbied for the ratification of the

IMO convention, recognizing greater restraints against oil transportation with the new legislation, backed Senator Mitchell's plan. Opposition was led by INTERTANKO as well as the British government, but the bill, to be known as the Oil Pollution Act of 1990, was signed into law by President George Bush. The inability of tanker owners, both national and international, to effectively lobby in the face of grassroots environmental support was seen as a major liability in their attempt to oppose national legislation (Suzuki 3).

Although Exxon assumed responsibility for the incident, intense legal battles followed for years in an attempt to secure punitive damages from the company. At the time of the incident Exxon immediately paid $300 million voluntary to 11,000 Alaskans whose livelihood had been affected by the spill, as well as contracting with all available local boats to assist in the cleanup. $2.2 billion was spent by the company between 1989 and 1992 to complete a thorough clean-up of Prince William Sound. By January 2004 punitive damages had been set in court at $4.5 billion, although this decision has since been thrown out by the Ninth Circuit Court of Appeals. The legal battle over the Valdez grounding has attracted significant industry attention because of its possible implications in future oil spills, but the ongoing nature of the case makes it difficult to understand what its lasting impact will be.

Impact of Valdez Incident on Alaskan Trade

Temporary disruption of the trade resulted directly from the spill. On March 25, 1989, pipeline shipments were reduced to 768,000 barrels per day. The Alyeska Marine Terminal could store seven days of shipment at this rate. This decision allowed

authorities to complete lightering operations of the Exxon Valdez and perform other functions in the sound without interference from vessel traffic.

The impact that the Valdez incident itself has had on the structure of the TAPS trade has been less significant than its role as a catalyst for the passage of OPA90. Although trade did resume, though cautiously, soon after the incident, the development of OPA90 legislation would leave a more lasting mark on the fleet and its operations.

Development of OPA90 Regulations

Proposals for a legislative response to the grounding of the Exxon Valdez came about with the objective of preventing another incident. Technological and operational initiatives were viewed as the means to accomplish these goals.

Operational changes sought after the Valdez incident focused on manning requirements and escort rules for tankers. Significant public attention focused on the suspected incapacity of the captain and inexperience of the watch officer navigating the vessel at the time of the incident. Outcry also forced legislators to incorporate new standards defining bridge manning and pilotage requirements, as well as stricter rules against alcohol and drug abuse by mariners. OPA90 legislation included provisions explicit to Prince William Sound, mandating pilotage requirements, a vessel traffic control scheme, and the development of an oil spill recovery institute. Provisions were also laid forth to streamline requirements for tug escorts in other sensitive waterways, including Puget Sound. Cooperation with Canadian legislators on this provision was encouraged.

Technological changes were also demanded as part of the legislative response. Requirements for double-hull construction for most tank vessels was a key demand, but

improved communications equipment and spill response gear was also cited as being necessary in preventing a similar future event.

Adoption of OPA90

The adoption of the Oil Pollution Act of 1990 created significant new restrictions on the TAPS domestic fleet as well as the few international tankers calling at Valdez. The OPA90 requirements directly affecting shippers can be categorized as follows:

- double hull construction on all new vessels operating in U.S. waters, and the gradual phase out of tankers of single hull construction by 2010 and tankers of double bottom or double side construction by 2015
- development of emergency response plans and provisions for containment of a spill of any possible size, up to 100% of cargo
- increased liability of shipowners trading in the U.S. from $150 per gross ton, established by the Clean Water Act, to $1200 per gross ton
- creation of a $1 billion Oil Spill Liability Trust Fund to ensure adequate funds for spill compensation above and beyond the shipowner's liability

Requirements that shipowners prove their ability to finance a major cleanup operation came in requirements for a Coast Guard-issued Certificate of Financial Responsibility (COFR). Traditional methods of ship insurance through Protection and Indemnity clubs were not suitable to these new requirements as clubs were unwilling to have their insurance leveraged as collateral for the COFRs. As a consequence regulations were reworked to allow for shipowners to obtain surety bonds based on 'other evidence' of self insurance and the approval of commercial reinsurance that would serve as

leverage for meeting COFR requirements. The significant changes in the concept of shipowner liability and fleet regulation that OPA90 created would affect tanker operations worldwide, but the most significant legacy would be with the Jones Act tanker trade itself. The TAPS trade would consequently be faced with new restrictions that would significantly alter its operations soon after the adoption of OPA90, and would set the foundation for the future of the Alaskan oil trade.

Challenges to Legislative Action

Opposition against many aspects regulating tanker design through the Oil Pollution Act of 1990 has emerged from many sectors. Vessel operators with fleets of non-OPA90 compliant tonnage that would eventually be subject to mandatory retirement were most interested in other safety alternatives. However, the sensitive political environment following the incident made lobbying against proposed regulations, no matter how restrictive, very difficult.

Although OPA90 was passed with the understanding that states would be allowed to adopt their own provisions to strengthen antipollution measures, such was not done immediately after the passage of the federal legislation. In 1995 the State of Washington adopted regulations requiring tankers trading in the state to adopt 'best achievable protection' technologies to avoid environmental incidents. The potential implications of such an amendment on the tanker fleet, still adjusting to operations in a post-OPA90 market, were serious. What defined 'best achievable protection'? INTERTANKO immediately began a legal battle against this legislative action which continues to date.

EFFECTS ON PRE-OPA90 FLEET

Immediately after implementation of OPA90 legislation Lamb and Bovet cited the following impacts that OPA90 was likely to have on Jones Act shipowners:

- Declining asset values due to artificially accelerated phase-out dates for single-skin tank vessel tonnage
- Increasing operating costs due to enhanced safety, spill prevention, and response measures imposed by Congress and regulatory authorities despite lack of evidence that U.S.-flag tankers would command premiums on international trading routes
- Risk of financial ruin for individual tanker owners or operators greatly increased due to liability associated with a single catastrophic incident
- Increased long-term partnerships with charterers- the closer linkage between independents and oil company charterers will be required to ensure that the charterers' safety standards are met and that the money is provided to carry out the investments needed
- Quality increase in the long term but may increase or decrease in the short term (156)

As the world market continues to absorb post-OPA90 tonnage, its effects on older vessels can be felt. Two different scales of valuation exist. In the domestic TAPS trade this has been more difficult to measure due to the slow absorption of new tonnage and phase-out of single-skin vessels but it is clear in international markets.

Potential for Vessel Conversion

Declining asset values due to accelerated phase-out dates for single-skin tonnage threatens the investments of many shipowners. The high capital costs associated with Jones Act tanker construction, as well as the possibility of capturing all trading potential of current vessels, has led to the development of technologies that would allow current non-compliant TAPS tonnage to meet OPA90 specifications through a minimum amount of adaptation. Developing ways to make single-hulls into double-hulls has been a business area for several marine consulting firms. As phase out deadlines approach, it is likely that demand for these services is going to remain great, particularly if no significant changes in either vessel demand or construction costs occur.

Modifications to existing single-hull tanks may be made by creating a double hull within the existing tank, essentially adding an inner skin to the existing hull. This is a delicate and time-consuming process which requires significant structural modification both inside the tank and on the deck above (to facilitate construction). Another alternative is the construction of a 'blister' around the existing hull, creating a double skin outside of the existing hull. This option has significant advantages in terms of fabrication over constructing an inner skin inside current tanks, but may adversely affect the hydrodynamic properties of the hull. The alternative of adding an inner hull is strongly advocated by Maritrans, which has successfully performed this operation on barges in order to bring them into OPA90 compliance.

Hybrid approaches may also interest some shipowners. The costs of converting all tanks on a vessel may make partial conversion an attractive option. Alternatively, hull sections may be replaced outright by fitting of a new midships section, preserving

existing machinery spaces. Converting tankers for other trades entirely, such as to bulk carriers, may also occur, although legislation on this front threatens to place similarly restrictive requirements on these vessels.

Mandatory Retirement

OPA90 legislation places mandatory retirement dates on single-hull vessels. It is likely that because of the advanced age of most of these vessels they will cease trading at these dates. However, for the younger vessels, retrofitting with OPA90-compliant double hull solutions can not be excluded as an option, particularly when regarded with respect to newbuilding costs.

It is unlikely that owners will readily take existing vessels out of service for ambitious conversions until absolutely necessary due to the lost productivity and high costs of conversion. Other risks are also inherent in making the conversion before reaching the phase-out date, such as questions about steel integrity or machinery needs that may arise later in a ship's life. Although slowly growing now, the market for vessel conversions will become much more significant as phase-out dates affect younger tankers in the TAPS fleet.

EFFECTS ON POST-OPA90 FLEET

Although OPA90 is generally noted with respect to the effects that it will have on removing existing tonnage from trading, its effects on the future of the tanker fleet is significant as well. Levels for future technological standards have been created by the legislation, although they are not always specifically spelled out in the terms of the act. Rather, the spirit of requiring vessels to be equipped with all reasonable measures to

mitigate the risk of pollution in itself places significant initiative on shipowners to bring their tonnage in line with the most advanced available in the market. The demand of charterers for this premium tonnage in the wake of the punitive judgment against Exxon is further encouragement for a technologically advanced post-OPA90 fleet.

Development of New Fleet in Early 2000s

Although fleet renewal is perceived as a continuous process, in the maritime trade it traditionally comes in bursts based on market cycles, economic conditions, and shipyard capacity. In Jones Act trades fleet renewal is generally less tied to market conditions than in international trades.

In the early 2000s, BP was among the first ship operators to build a series of vessels in the post-OPA90 market. These vessels have attracted significant attention not only because of their advanced design but also for their high cost. BP's investment in this expensive project shows a distinct new attitude in the post-OPA90 market that is in accord with the legislation's spirit. Future newbuildings are likely to be constrained by the higher standards now introduced into the fleet.

Design of New Vessels

The new BP tankers represent the likely specifications for future vessels in the TAPS trade. Their principal characteristics are as follows:

- LOA: 287.25m
- Beam: 50.00m
- Depth: 28.00m
- Design draft: 18.75m

- Speed at 85% MCR: 15.3 kts
- Cargo capacity (98%): 1,300,000 bbls
- Design deadweight: 185,000 t
- Design displacement: 220, 966 t
- Lightship weight: approx. 35,950 t (NASSCO 1)

Although the principal characteristics of these vessels are not especially unique to the TAPS trade and do not represent any significant deviation from the pre-OPA90 standards, the safety systems that these vessels incorporate significantly raise standards among the fleet and are outlined in Appendix B. The significant redundancy built into these vessels illustrates the importance with which vessel designers will have to regard safety systems in newbuildings. By raising standards all new vessels will need to comply or risk gaining a reputation as an operator with sub-par safety standards.

Costs of New Vessels

The BP tankers were supplied as part of a three-vessel, $630 million contract. Although some savings could be obtained by simplifying the powering system to a conventional single-screw low-speed diesel design, the regulatory and economic realities of operating in the post-OPA90 TAPS trade will probably preclude this. Again, the investment seems necessary for shipowners desiring to act in accord with the OPA-90 legislation.

The high price of the three-vessel series is a consequence of many factors, mostly related to the nature of Jones Act shipbuilding. These will be discussed in detail later.

Influence of Public Image and Environmental Activists

A negative public image has been a significant factor in the plight of tanker operators worldwide. Poor relations and a perceived lack of transparency were some of the factors that led to the passage of OPA90 and have constrained efforts for fleet self regulation (Kulukundis 3). Improving public image and relations with environmental groups, in addition to transparent compliance with national and international anti-pollution regulations, are essential steps in rebuilding the industry's image. INTERTANKO has been a central force in improving relations with environmental groups.

A positive public perception of environmental consciousness and prevention initiatives being taken by all participants in the TAPS trade is essential in order to make the trade successful in a post-OPA90 world. This requires true effort on the part of tanker operators, not only those engaged in the TAPS trade, but all those who are visible to an influential public. Art Davidson, concluding his work In the wake of the Exxon Valdez, stated:

> In the end, prevention is the only real defense against large oil spills. As the Oil Spill Commission concluded, "Prevention of oil spills must be the fundamental policy of all parties in the maritime oil transportation system... This disaster could have been prevented- not by tanker captains and crews who are, in the end, only fallible human beings, but by an advanced oil transportation system designed to minimize human error. It could have been prevented if Alaskans, state and federal governments, the oil industry, and the American public had insisted on stringent safeguards.
>
> Admittedly, the tools of prevention- double-hulled tankers, the best electronics, and redundancy in critical systems, highly trained crews, and heightened Coast Guard surveillance- are imperfect. Shipping oil in tankers will never be risk-free, but being mindful of this fact will reduce the risk. Realizing that there will be tanker accidents is the first essential step in avoiding them.

> Once the pipeline was built, tankers loaded with North Slope crude transited Prince William Sound 8,700 times without accident. This very success fostered complacency, which led to the neglect that added substantially to the danger. Finally, a snowballing of errors and circumstances resulted in a grounding of disastrous proportions. The way to prevent another accident is to fight the complacency, and to do that, we must be mindful of two basic, irrefutable facts- major spills happen, and when they do, they cannot be controlled. (307)

Quality has been necessarily increased in order to meet stronger safety, liability, and anti-pollution requirements. Charterers, fearing their own liability in an incident involving their cargo, whether or not actually involving their own ship, have shown themselves willing to pay premiums for high-quality tonnage in order to reduce their own risk. This trend has been reflected in Jones Act trades but is also characteristic of several international operators. Whether or not this trend will last for the long term will probably not be known until another serious spill occurs and the 'new liability' is tested in courts.

PROSPECTS OF THE ALASKAN OIL TRADE

The future of the Alaskan oil trade is dependent upon the economic viability of continued crude production as well as the supply outlook, both domestic and international. While it is clear that Alaskan oil will not be accepted as the primary source for domestic needs, there is a clear value in production for national security purposes. Potential drilling in the Alaskan National Wildlife Refuge may also significantly impact the future of the trade by significantly increasing supplies and potentially lengthening production lifespan. These various forces could impact the TAPS tanker trade in a variety of ways.

FUTURE OF ALASKAN PRODUCTION

Although production has been decreasing at existing fields, new attention is being focused on potential reserves elsewhere on the Alaskan North Slope. A summary of potential field developments are shown in Table 3.

Field	**Proven Reserves**	**Potential**	**Status**
Developed Fields			
Prudhoe Bay	12,045	2,000 to 4,000	Supergiant
Kuparuk	2,201	1,000	Giant
Endicott	456	200	Probable giant
Lisburne	201		Lower than expected
Port McIntyre	307	200	Probable giant
Milne Point	118		Marginal field
Niakuk	47		
Identified Prospects			
West Sak	148	1,000 to 10,000	Giant? Supergiant?
North Star-Seal Island area	200	1,000	Smaller fields
Coleville Delta		1,000	Giant?

Kuvlum-Wild Weasel		1,000	Giant?
Badami area		1,000	Giant?
Point Thompson	200	1,000	Giant?
Total	*15,923*	*3,000 to 20,400*	*A dozen giants?*

Table 3: Crude oil reserves and potentials (millions of barrels). (Van Vactor 1)

Until exploration and test drilling are completed the scope of future production will remain unknown. The complexity of field development may delay commercial export for up to 10 years. Statistics by the Energy Information Administration's Office of Oil and Gas rates total potential production in terms of mean cases, 95% probability cases (most pessimistic), and 5% probability cases (most optimistic). Historical production trends in addition to these three potential cases are illustrated in Figure 2.

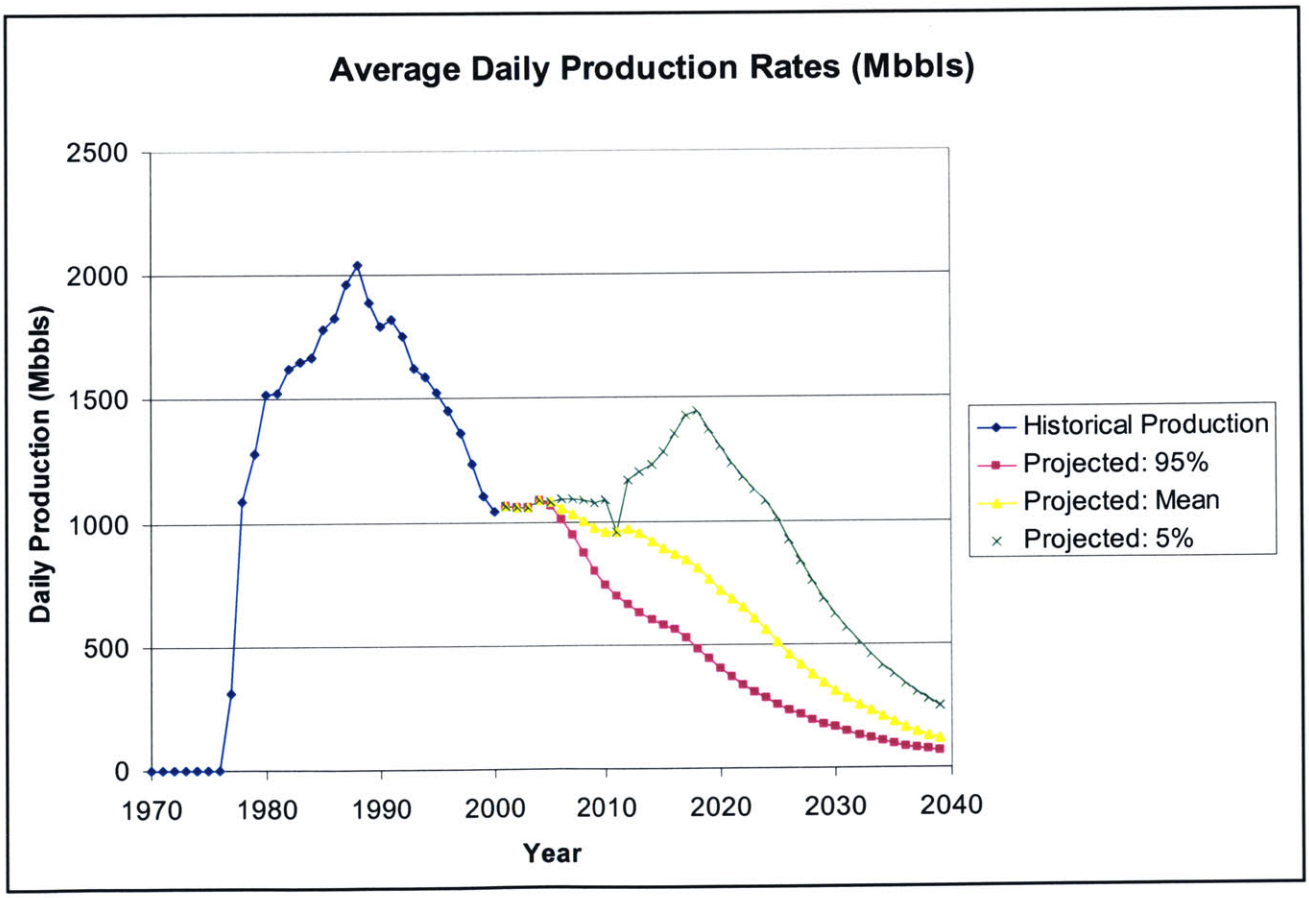

Figure 2: Average daily production rates, historical and projected (Energy Information Administration)

Challenges to Drilling Projects

Criticism to increases in Alaskan production has emerged as production prospects have emerged. Most intense debate has been centered on proposals for opening the Alaskan National Wildlife Refuge to drilling. Although a potential source for very large quantities of oil, the damage that exploration and production could do to the region's ecosystem has attracted harsh criticism from environmental groups.

New sources of oil on the North Slope would strongly influence the future of the TAPS trade. As existing production sites decline and per-barrel production and transportation costs rise, new sources of oil are critical for the longevity of the trade. Predictions are that without the new oil the TAPS trade could decline to pre-2000 levels by 2008.

Status of TAPS and North Slope Production

A March 16, 2005, senate vote included provisions for opening the region into the year's budget. Although indications are now that drilling in the region is imminent, the long exploration and development process makes it unlikely that the region's production will significantly impact the TAPS trade for many years.

ANALYSIS OF FUTURE SERVICE DEMAND

Service demand will be dependent upon future production. In estimations of the future of service demand several factors must be considered. Central to the question of TAPS service demand is the supply of crude. Excess Jones Act tonnage can not be readily absorbed into other trades due to its extremely high capital and operating costs so vessel supply is likely to be influenced only by production demand. At the same time,

however, mandatory fleet retirement is putting time constraints on operators. Analysis of fleet capacity and production levels can be used to explain this problem.

Economic realities would promote using vessels as large as possible to operate in the TAPS trade to reduce expensive manning costs and minimize the transportation price per-barrel of oil. However, draft, construction, and financial realities dictate reasonable limitations to vessel sizes in the future. Size restrictions and characteristics of the Alyeska Marine Terminal are outlined in Appendix C. The dimensions of future vessels in the trade will be limited to the capacity of the Valdez terminal. As modern vessels are at the threshold of terminal capacity, it is unlikely that future vessels will deviate significantly from the current fleet.

Fleet Capacity Considering Operating Tonnage

The effects of OPA90 and tonnage phase out will have marked effects on the TAPS fleet in the coming years. The declining trend in vessel capacity is illustrated in Figure 3. Figure 4 illustrates this trend in relationship to oil production predictions.

Tonnage reduction began in 2005 and by 2008 fleet size will be reduced to approximately 60% of 2004 levels. The nature of Jones Act trades is such that market equilibriums have created balanced supply and demand levels, and unless production rates decrease correspondingly, by 2008 serious undercapacity in the TAPS trade will be expected.

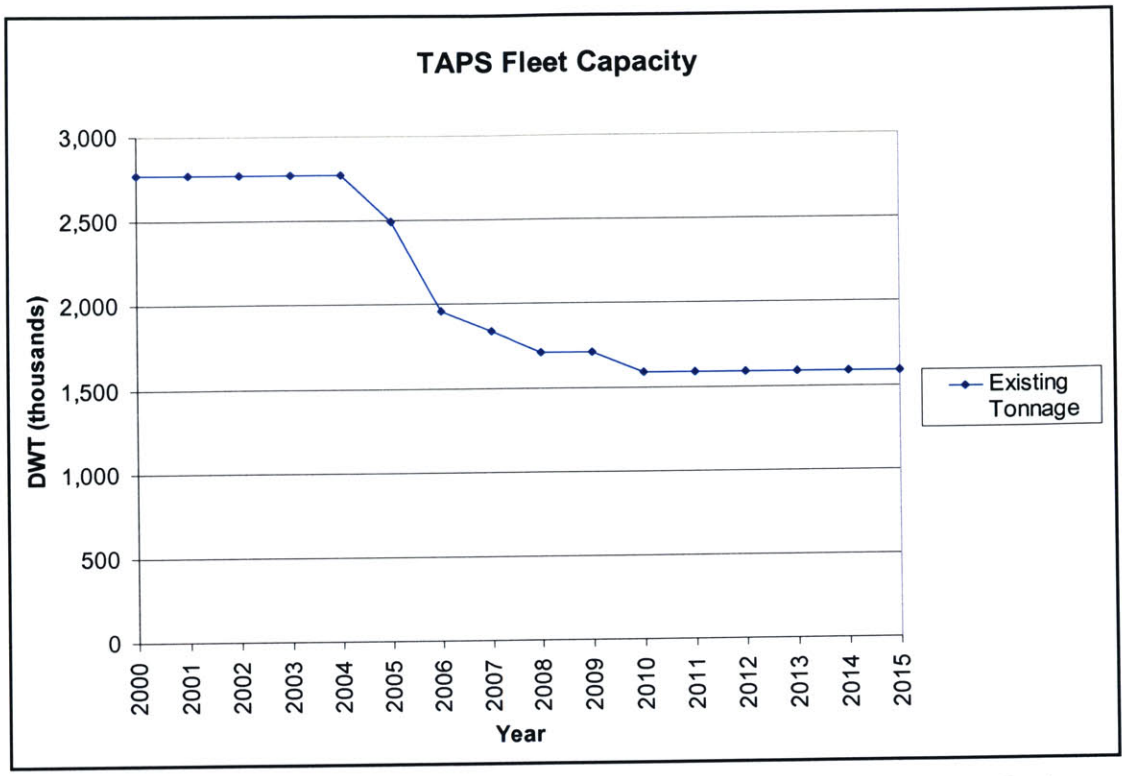

Figure 3: TAPS fleet tonnage accounting for mandatory phase-outs. (Maritime Business Strategies US Fleet Statistics, ABS Record)

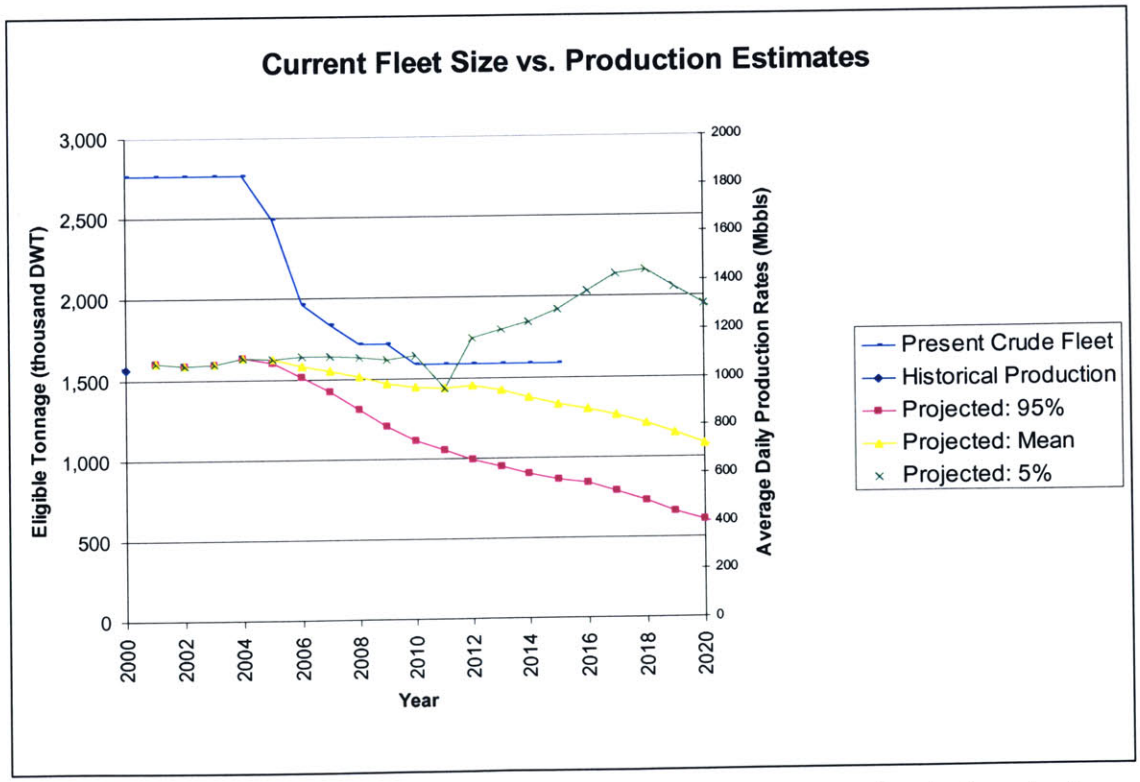

Figure 4: Current TAPS tonnage accounting for phase outs and predicted oil production (Maritime Business Strategies US Fleet Statistics, ABS Record; Energy Information Administration)

The decline in oil production levels, assuming mean or 95% production predictions, occurs much slower than tonnage phase out. If either of these projections proves valid, undercapacity will likely exist in the TAPS tanker segment. If 5% production projections prove valid, current production levels will remain relatively steady until 2010 after which time they will steadily increase. Current TAPS tonnage, much of which will be phased out by this date, will certainly not be capable of meeting trade demand.

VESSEL ACQUISITION

Operating in the TAPS trade in the post-OPA90 market will still require the expensive tonnage that Jones Act trade has necessitated for domestic trades for decades. Additionally, the realities of the charter market may limit new entrants mostly to operating on short-term charter or spot bases. In essence, the high barriers to entry in this trade have kept the market in balance and are likely to continue doing so in the near future.

Expansion or renewal of the TAPS fleet will require Jones Act-qualified tonnage. This restriction requires that vessels be built in US shipyards. New vessels entering the TAPS trade may come from two sources: newbuildings or Jones Act tankers currently serving in other markets. The market realities of the latter group make their entry unlikely except under specific conditions, notably a downturn in all other domestic market except the TAPS trade. Changes in American refined chemical manufacturing, requiring product carriers, could result in these clean ships entering dirty trades.

Expansion from Existing Jones Act Fleet

The future of the domestic clean product and chemical trades is in doubt. Forced phase-outs due to OPA90 regulations will significantly deplete the trading fleet over the next two decades. A detailed clean fleet list is given in Appendix D. The future of clean fleet tonnage accounting for phase outs is given in Figure 5.

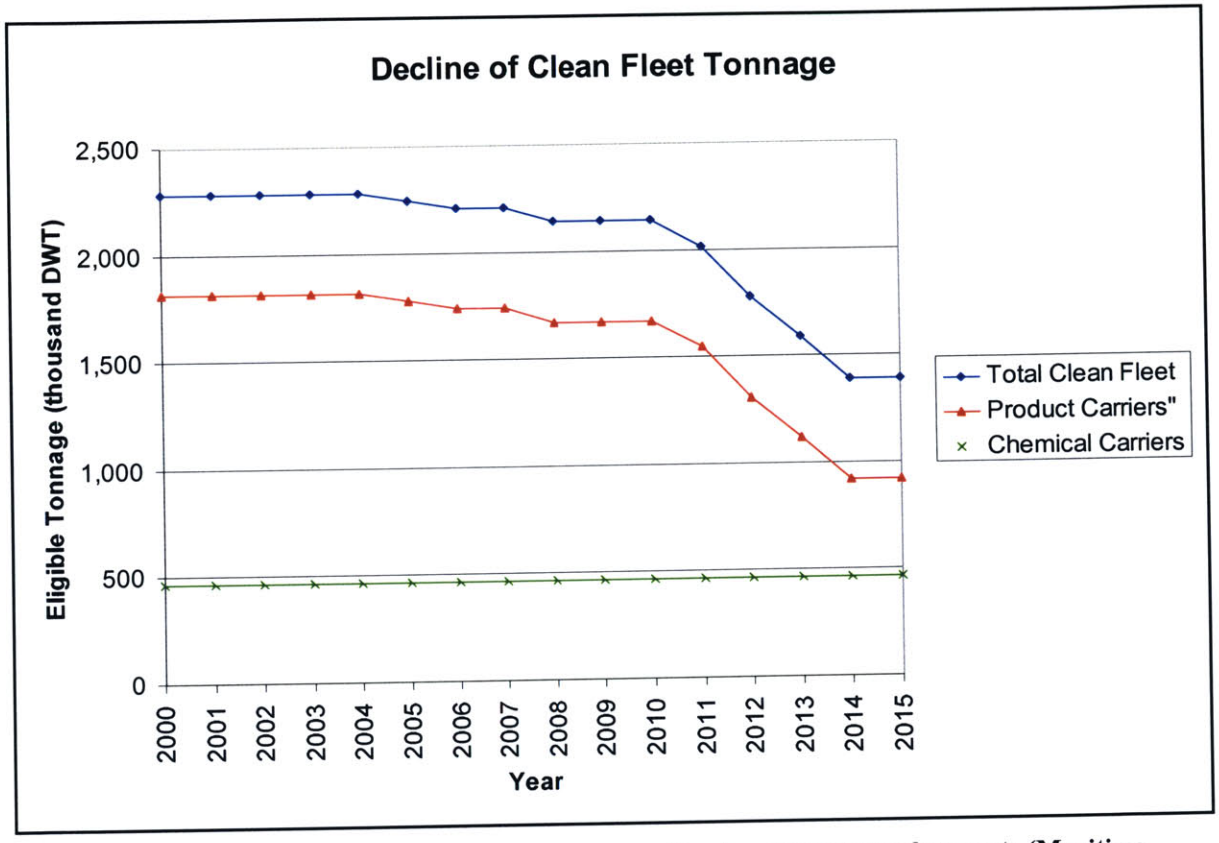

Figure 5: Jones Act clean fleet, tonnage accounting for mandatory phase outs (Maritime Business Strategies US Domestic Fleet, ABS Record)

Expansion by New Construction

Domestic shipyard will present challenges to any expansion of TAPS trade which requires the construction of Jones Act tonnage. Presently there are six major US shipyards recognized as having the abilities to construct a vessel of the size required. They are generally known as 'gray shipyards' because of their military work, but have the facilities capable of commercial building:

- Bath Iron Works
- Newport News Shipbuilding
- Avondale Shipyards
- Ingalls Shipbuilding
- NASSCO
- Electric Boat

In the 1990's Newport News Shipbuilding completed construction of the 40,000 DWT Double Eagle series of clean product tankers. Due to the significant cost overruns and logistical challenges involved in attempting to transition a military shipyard operating on cost-plus contracts to a commercial shipyard operating on fixed contracts, it is not expected that Newport News Shipbuilding will attempt to enter the commercial market again.

The successful delivery by NASSCO of three tankers for Alaskan service to BP poises them to maintain their position as perhaps the only commercially viable tanker builder in the US. The cost of the contract- three vessels for $630 million- illustrates the massive costs associated with such a contract.

After completing a series of four containerships for Matson's Hawaii trade, Kvaerner Philadelphia Shipyard expressed interest in tanker construction in the future. The yard has the facilities needed to efficiently build needed vessels but only has experience in containership construction. They have the distinct advantage, however, of being supported by one of the largest international shipbuilding consortiums that no doubt could provide much guidance and support for an ambitious domestic shipbuilding project.

Domestic shipyards have continuously shown themselves inflexible to lower prices demanded by ship owners and hence many potential newbuilding deals have been scuttled purely on the basis of price. Owners have demanded 25,000 DWT product tankers in the $70-$75 million range and yards have held firm at about $90 million (Miller 21 Apr. 2005 6).

It may also be time that ship owners look beyond the traditional gray shipyards and at smaller yards that have build experience with tug-barges and small craft. Bollinger Shipyards in Louisiana and Texas have emerged as potential contenders for new tanker construction programs.

COST CONTROL IN TAPS FLEET EXPANSION

The February 2005 United States Government Accountability Office report entitled Defense Acquisitions: Improved Management Practices Could Help Minimize Cost Growth in Navy Shipbuilding Programs outlines many of the factors that contribute to the high cost of shipbuilding at America's largest shipyards. Cost growth in several U.S. Navy projects was analyzed. For eight ship assessed by the GAO total cost growth was expected to reach $3.1 billion. The components of cost growth are illustrated in Figure 6.

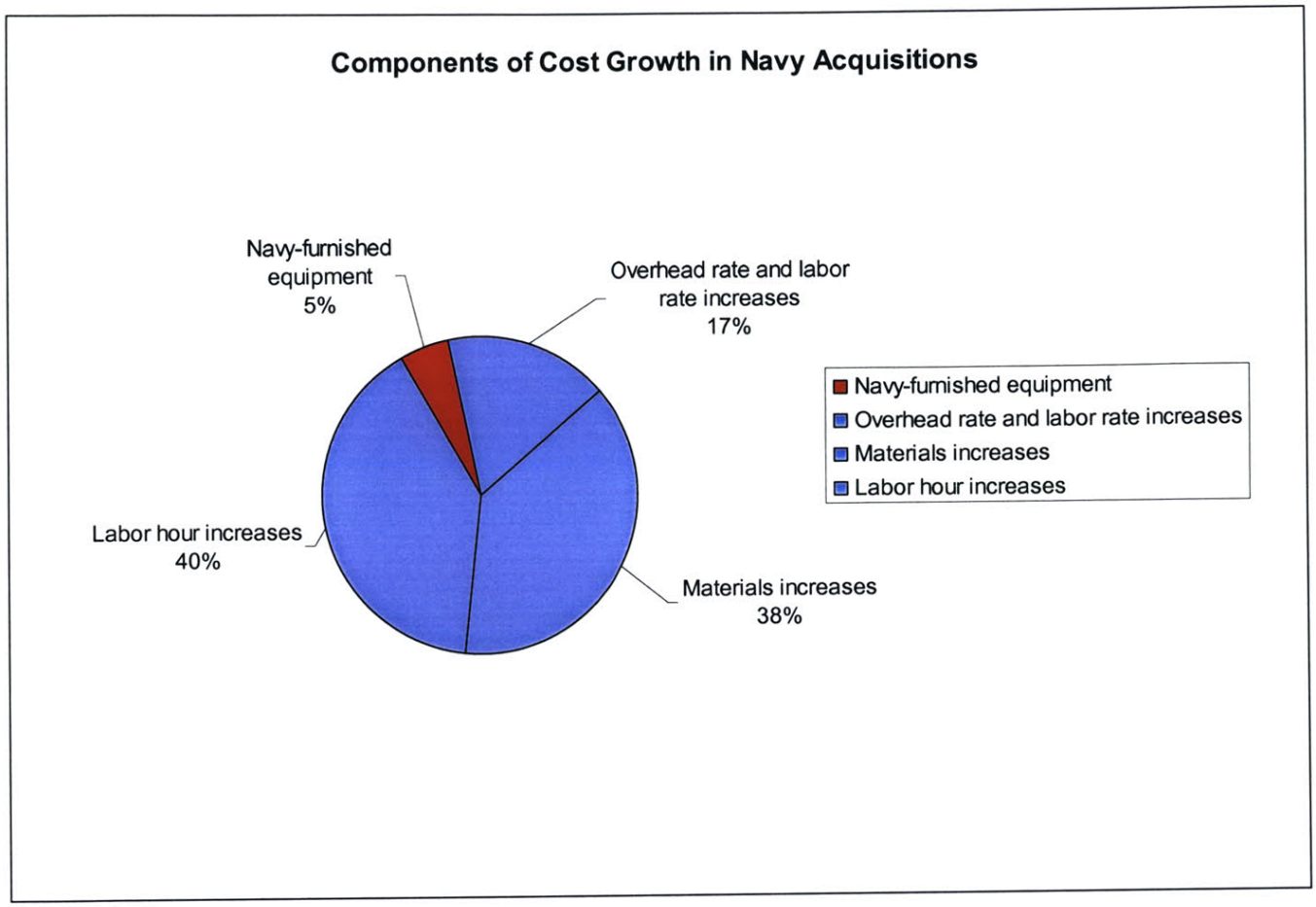

Figure 6: Components of cost growth in Navy programs. (GAO 11)

As can be seen from Figure 6, 78% of cost growth on Navy shipbuilding contracts was a result of increases in labor hour and materials costs, while overhead rate and labor rate increases accounted for 17% of cost growth. Navy furnished equipment accounted for only 5% of cost growth. Clearly, the burden is on shipbuilders in controlling the cost growth in shipbuilding projects, although the GAO has identified by writing the report that the Navy must assume certain responsibility in rectifying this trend.

In order to economically construct vessels for the TAPS trade the same cost controls will need to be applied by shipyards to commercial construction programs. Certain key elements of the component areas have been identified by the GAO where cost control measures are most needed, listed in Table 4.

Labor	Materials	Overhead
• Hours needed for production, engineering, and support functions • Hourly rates and associated hourly costs	• Metals (steel, copper, titanium) • Tools • General parts (pipe, cables, etc.) • Subcontracts	• Medical insurance • Pensions • Holiday and vacation pay • Maintenance and utilities • Taxes

Table 4: Shipbuilding cost categories targeted for reduction. (GAO 6)

The long production times involved in Navy ship construction- up to 7 years for an aircraft carrier- contribute a large amount of uncertainty when cost estimates are initially made, but cost overruns are still prevalent in short-term construction programs. Techniques for controlling cost growth may include hedging core component prices, such as for steel, where volatility could significantly impact expenses. Additionally, better relationships with workers and unions are needed to control labor costs.

General feelings of indifference toward cost growth is endemic in shipyards long adjusted to cost-reimbursement (cost-plus) contracts, and institutional change must be deep in order to operate in a commercial, fixed-cost market. In this respect smaller, traditionally commercial shipyards may be at an advantage over established large-scale shipbuilders in being able to deliver vessels on schedule and at contract price. Furthermore, shipyard 'knowledge' may simply not be in place. The GAO report states, "The lack of design and technology maturity led to rework, increasing the number of labor hours for most of the case study ships (12)." Yards may be in need of education in modern shipbuilding techniques so as not to experience such learning curves during construction.

Shipbuilders have responded with their own claims about why costs have risen so sharply for many Navy programs. Factors cited in the GAO report included:

- Inexperienced laborers
- Introduction of a new construction facility
- Strike increasing number of hours needed to complete ship
- Less-skilled labor on project due to demands for labor on other programs at shipyard
- Extensive use of overtime
- Inexperienced subcontracted labor
- Bussed workers to meet labor shortages
- Late material delivery
- Quality problems and design changes (13)

Labor problems are a central problem facing shipyards and must be addressed before commercial projects can begin. Building a skilled, versatile, dedicated shipbuilding team should be a priority for shipyards interested in reducing cost uncertainty, production delays, and dependence on cost-reimbursement contracts. Such will be necessary in competitive construction of TAPS vessels.

Overcoming steep learning curves is central to making newbuilding economically possible and to achieve this large vessel series are needed. The proposed $1 billion vessel series to be built at Kvaerner Philadelphia Shipyard is expected to produce vessels that cost $150 million each at the beginning of the series. Vessel costs will reduce to $50 million per vessel by series' end. This will reduce average vessel price to about $83 million (Miller 21 Apr. 2005 6).

Government Assistance to Trade

U.S. government programs, organized through the Maritime Administration (MARAD), have attempted to address market realities facing U.S. deep-sea shipping operators. Title XI financing provides mortgage guarantees which have been major factors in previous domestic shipbuilding programs. It is likely that such programs may in the future provide incentives for new vessel construction for the TAPS trade. Budget uncertainties, however, create some risk as to the availability of this program for future TAPS newbuildings.

The Maritime Security Program coordinates vessels that may be called to serve Department of Defense needs for national security needs. Approximately $100 million is divided among the 47 ships participating in the program to act as a subsidy due to the higher acquisition and operation costs of this Jones Act tonnage. Few tankers are involved in this trade, however. Most participating vessels are container carriers and RO/ROs. Nevertheless, the program may appeal to potential TAPS operators looking for funds to reduce annual operating costs.

The U.S. government has continued its initiatives to ensure the future of the U.S. flag fleet through the passage of the National Defense Tank Vessel Construction Program (NDTVC), a provision of the Maritime Security Act of 2003. The program is designed to provide funds to assist in the construction costs of up to five privately-owned U.S. flagged product tank vessels, engaged in "commercial service in foreign commerce", with the following characteristics:

- Size 35,000-60,000 T, approximately 250,000 bbls
- Capable of a minimum of three cargo segregations

- Epoxy coated cargo tanks
- Proposed operator must have the ability, experience, and financial resources necessary for the operation and maintenance of the vessel

The program will pay up to 75% of the vessels' construction costs, up to $50 million (each). The principal purpose of the vessels would be to carry petroleum products for military use when required for national security, in alignment with the Secretary of Defense's Emergency Preparedness Plan, section 3543(e). Although the domestic nature of the TAPS trade may disqualify such vessels from affecting the Alaskan trade, future generations of this legislation may waive the foreign commerce stipulation. $50 million would account for 75% of a vessel whose cost would be $67 million, a price that U.S. shipyards may not be able to achieve.

The requisite U.S.-flag nature of this legislation will directly impact American shipbuilding and operation capabilities, which may affect TAPS vessel construction in the future. Requests for proposals were issued on February 20, 2004, and final evaluation (phase II) was completed on December 20, 2004. No information on the selections of MARAD has yet been published, but attendees of a January 28th, 2004 project meeting represented a variety of shipping companies with interests in the TAPS trade, directly or indirectly, including OMI, Seabulk International, Horizon Lines, APEX Marine, and K-Sea.

RECENT DEVELOPMENTS

The uncertain future of the TAPS trade and the potential changes in capacity and demand make this a fascinating time for the Jones Act fleet. TAPS operators are attempting to secure existing tonnage to maintain operations as OPA90 phase outs take effect. Newbuilding is unavoidable, but what shape TAPS newbuilding programs will assume is just beginning to emerge.

EXISTING VESSEL PURCHASES

In March 2005 SeaRiver announced that they purchased the 'Kenai' and 'Tonsina', built by Sun Shipbuilding (described as 'far-sighted' 10 years before OPA90 to meet its Alaskan trade needs (Maritime Business Strategies , 01Q2005)). SeaRiver is facing significant tonnage reduction due to compulsory OPA90 phase outs. The acquisition of the 'Kenai' (1979, 125,091 DWT, 64,329gt, 17 kt.) and 'Tonsina' (1978, 122,805 DWT, 64,329gt, 17 kt.)will be necessary steps for them to maintain current operating share. The vessels were sold en bloc from Alaska Tanker Company to SeaRiver Maritime for $50 million (Fairplay 353 24 March 2005 39).

NEWBUILDINGS

The potential impact that the Kvaerner Philadelphia Shipyard will have on the future of commercial shipbuilding in the United States may be significant. A recently announced deal with Overseas Shipmanagement Group (OSG) will make both Kvaerner and OSG key players in the future of the Jones Act tanker trade.

OSG/Kvaerner Philadelphia Shipyard Newbuildings

The opening of the Kvaerner Philadelphia Shipyard in 2001 presented new opportunities for commercial shipbuilding in the United States. An industry that had grown to focus primarily on national defense contracts now has a modern shipbuilding facility with the technological potential to compete with foreign shipbuilders. Jones Act shipowners would now have a source for tonnage capable of bringing new focus and efficiency to American shipbuilding.

Kvaerner Philadelphia Shipyard (KPSI) initially contracted to build two 2600 TEU containerships for Matson Navigation Company at a reported cost of $110 million each (Kvaerner 2002 1). Two more containerships began construction on speculation but were later contracted by Matson at an estimated cost of $290 million following the failure of Ocean Blue Express, a failed startup company planning to operate the ships in direct competition with Matson. The final ship in the series of four is scheduled for delivery in June 2006. Matson also was granted a right of refusal for four additional containerships for delivery before June 2010 (Kvaerner 24 Feb. 2005 1).

On 14 April 2005 KPSI and Overseas Shipmanagement Group (OSG) announced partnership on a $1 billion tanker deal following speculation that KPSI was next looking to enter the tanker construction sector. The contract calls for the construction of 10 Hyundai-designed Veteran MT-46 class Product Tankers for the Jones Act trade, as well as an option for two additional vessels. The ships will be owned by a KPSI subsidiary and bareboat chartered to OSG for terms of 5 to 7 years. The chartering deal is worth an estimated $500 million (OSG 1, Kvaerner 14 April 2005 1). Technical details of the MT-46 tankers are listed in Appendix B.

The 46,000 DWT tankers are expected to be delivered at a rate of three per year, significantly increasing the capacity of the product tanker fleet. All vessels are planned for delivery by 2010. Figure 7 illustrates the annual shift such deliveries will have on the current fleet.

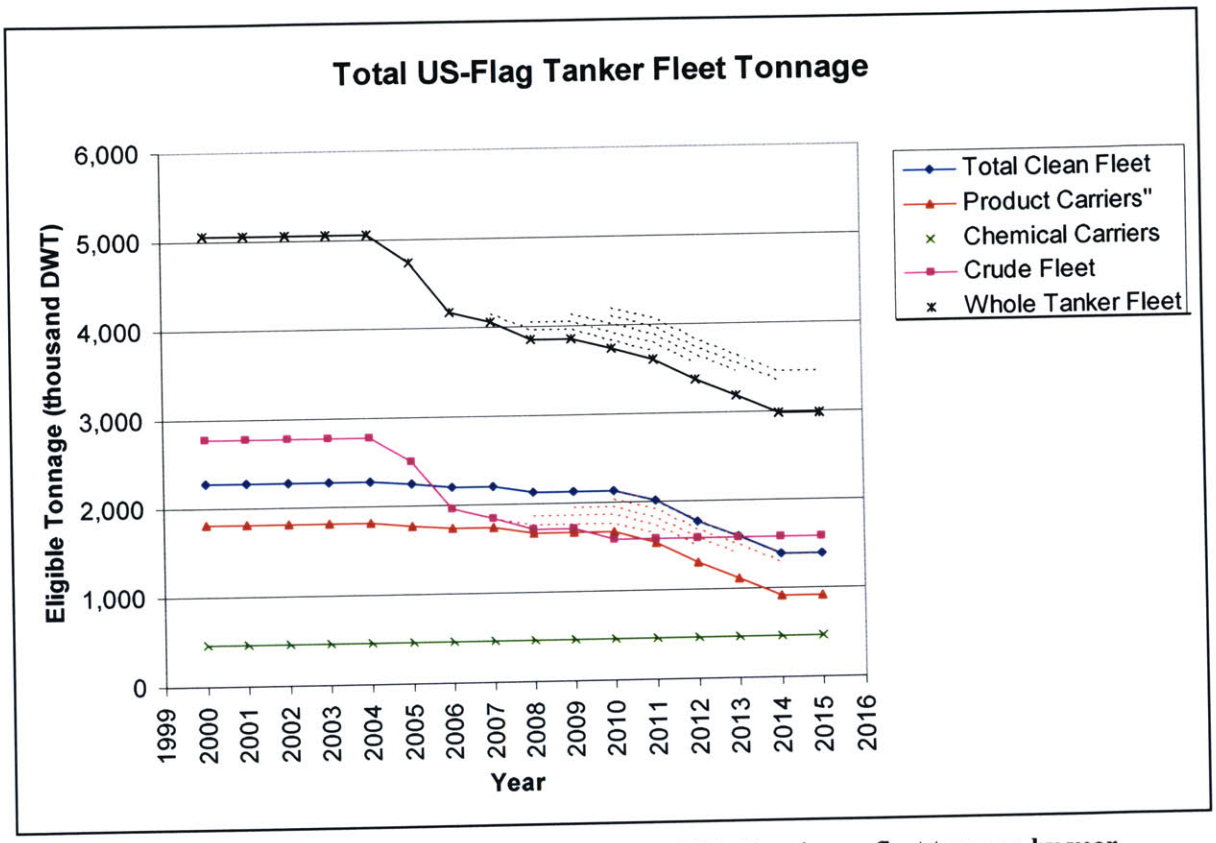

Figure 7: Impact of proposed 10-vessel Veteran MT-46 series on fleet tonnage by year.

The addition of 10 new 46,000 DWT product carriers to the Jones Act fleet will effectively shift fleet capacity approximately 5 years; that is, 2010 levels will correspond to 2005 levels, and the effects of vessel phase outs will be felt more slowly. Although this will provide some temporary relief, this construction program alone will likely not meet long term capacity needs, especially if production rates increase.

OSG currently operates 10 Jones Act vessels, 7 of them tankers, detailed in Table 5. The addition of 10 more vessels will make them the most powerful shipper in the TAPS trade.

Vessel Name	Year Built	DWT	Construction Type	OPA90 Phase Out	Operator
Crude Carriers					
Overseas Washington (1)	1978	91968	DB	1-Mar-06	Alaska Tanker Company
Overseas New York (1)	1977	91844	DB	8-Dec-05	Alaska Tanker Company
Overseas Chicago (1)	1977	92092	DB	30-Jun-05	Alaska Tanker Company
Product Carriers					
Overseas New Orleans (2)	1983	43643	DB	30-Jun-13	Maritime Overseas
Puget Sound	1983	50860	DB	21-May-12	SeaRiver
S/R Galena Bay	1982	50920	DB	6-Oct-12	SeaRiver
Overseas Philadelphia (2)	1982	43387	DB	10-May-13	Maritime Overseas

Table 5: OSG Jones Act fleet list, tankers. (1) Vessel subject to securitized financing (2) 22-year capital lease expiring in 2011 (OSG Fleet List)

Other Potential Newbuildings

> After years of newbuilding inactivity, the market is abuzz with talk of imminent product tanker orders at US yards. As OPA90 withdrawals tighten capacity and rates rise, new tonnage might finally be added. (Miller 14 Apr. 2005 22)

The collaboration between Kvaerner and OSG to build a large series of new vessels has created renewed interest among TAPS vessel owners about fleet expansion possibilities. The innovative financing structure planned- a parent company (American Shipping) owning the vessels and the Kvaerner Philadelphia Shipyard bareboat chartering them to OSG for 5 to 7 years- has also attracted attention about new ways to raise capital for the construction of Jones Act vessels.

Shipyards and vessel operators have spent several years working on proposals for the National Defense Tank Vessel Construction Assistance Program (NDTVCA) in hopes that government subsidies, in the name of national security, would be made available to offset the costs of fleet renewal. Originally $250 million was planned to subsidize construction of five product tankers, but only $75 million in funds was able to be secured for the program's budget in 2004. In February 2005 the Bush administration urged Congress to rescind the $75 million and cease project funding entirely (Miller 14 Apr. 2005 23). Although the vessels to be used in the program were to be engaged in foreign trade, the subsidies could have helped to offset the expensive learning curve domestic shipbuilders would need to overcome to build affordable Jones Act tonnage.

Unconfirmed reports have circulated that Bollinger Shipyards has a letter of intent for four 30,000 DWT product tankers plus six options from Seacor, which has recently merged with Seabulk (Miller 14 Apr. 2005 23). Maritrans and Shell are also rumored to be considering newbuilding orders (Miller 21 Apr. 2005 7). However, Greg Miller of Fairplay, who has followed developments closely, states that such interest may come at a cost because:

> The first mover may hold the advantage, because the first 10-ship order could spook financers' confidence in a competing series. But the frontrunner will have to swallow the risks, because future freight rates are speculative and charter commitments may not be secured up front. (14 Apr. 2005 23)

Tug-barge systems have dominated domestic trades in recent years, their growth strong as the decline in conventional vessels in Jones Act trades has occurred. They have significantly lower capital costs, reduced crewing requirements, and more flexible, experienced builders. However, the vessels are slower, less fuel efficient, and dominate

river trades, not deep-sea shipping like the TAPS trade. They will probably not gain a foothold in the harsh environments that TAPS vessels operate in.

ANALYSIS OF CAPACITY CONSIDERING PROPOSED NEWBUILDINGS

The addition of ten 46,000 DWT product tankers may have significant implications on the TAPS fleet if the vessels are used to supplement diminishing capacity due to mandatory retirements in that service. This capability is illustrated in Figure 7.

Varying production rate estimates make the timing of vessel deliveries of particular interest. Although Kvaerner has stated plans for 3 vessel deliveries per year, service demands on the TAPS trade may or may not require tonnage addition at this rate.

Capacity Considering Estimated Production Rates

Analysis of fleet capacity needed to transport expected Alaskan TAPS production has been made with the following assumptions:

- Cargo density of 0.1477 t/bbl (0.89t/m^3) (Singer 5)
- All vessels loaded to 100% DWT capacity
- Each vessel makes 25 voyages per year
- All vessels engaged in TAPS trade as of 1 May 2005 will remain in trade until reaching phase-out date
- Years 2001 through 2039 are analyzed, although vessel phase outs are completed by 2015
- No new vessels may be delivered before 2007

Analysis of surplus or deficit vessel capacity has been made using the annual production estimates of the Energy Information Administration. Details of the analysis can be seen in Appendix E.

For the 95% probability case, the most conservative of the production estimates, no new vessels will be needed for the time period analyzed.

For the mean case, vessel capacity deficits will exist beginning in 2007. The years deficit vessel capacity will be encountered considering incremental 46,000 DWT vessel additions to the TAPS trade are listed in Table 6. Further details, including estimates of excess cargoes, are given in Appendix E.

Vessels Added	Year With Deficit Cargo Capacity
0	2007-2018
1	2007-2018
2	2007-2017
3	2007-2017
4	2008-2016
5	2008-2015
6	2009, 2011-2014
7	2011-2013
8	2011-2012
9 or more	No excess cargoes

Table 6: Years with deficit vessel capacity considering incremental additions to TAPS fleet and mean production estimates.

As can be seen from Table 6, current fleet capacity and an ambitious MT-46 newbuilding program can satisfy TAPS trade requirements if:

- Four vessels are delivered by 2007
- Six vessels are delivered by 2008
- Seven vessels are delivered by 2010

In order to meet the four vessel requirement by 2007 construction will need to begin immediately. Long-term demand requirements can be met by Kvaerner's stated program completion date of 2010.

For the 5% probability case, the most optimistic of the production estimates, vessel capacity deficits are also expected to occur beginning in 2007. The years deficit vessel capacity will be encountered considering incremental 46,000 DWT vessel additions to the TAPS fleet are listed in Table 7. Further details, including estimates of excess cargoes, are given in Appendix E.

Vessels Added	Years With Deficit Cargo Capacity
0	2007-2027
1	2007-2027
2	2007-2027
3	2007-2026
4	2007-2026
5	2007-2026
6	2007-2026
7	2008-2025
8	2008-2025
9	2009-2010, 2012-2025
10	2009-2010, 2012-2025

Table 7: Years with deficit vessel capacity considering incremental additions to TAPS fleet and 5% probability production estimates.

As can be seen from Table 7 construction of many MT-46 class vessels alone does not offset predicted future transport demand. More vessels will be needed in the trade. However, if larger crude carriers were constructed for TAPS service, need for the Kvaerner product carriers on that trade would be reduced. Considering the assumptions used in the model, approximately seven 80,000 DWT vessels would be needed to offset a 100,000,000 bbl capacity shortfall (this is approximately the mean value of the vessel capacity shortfalls for years 2007-2027 considering all possible MT-46 delivery scenarios).

Under these production estimates vessels larger than 46,000 DWT product tankers may be better suited for TAPS trade, such as 125,000 DWT VLCCs. If optimistic production estimates are valid, larger crude carriers with simpler coatings and tank arrangements could be economical in the trade. Five 125,000 DWT ships would be needed to offset the mean capacity shortfalls for years 2007-2027 considering all possible MT-46 delivery scenarios.

Vessel Versatility and Production Rate Estimate Accuracy

The year-by-year variability in vessel needs for several of the production cases considered illustrates the importance of versatility in TAPS vessels. Vessels specifically designed for the TAPS trade may suffer from a lack of work, and the limited scope of work for vessels in Jones Act trades and stiff competition on international routes makes the investment uneconomical if steady revenues can not be guaranteed. Hence it is important that versatile product tankers be added to the trade that have the potential of finding work on other domestic routes during lesser-productive years in Alaskan oil fields. Crude carriers that have few other options would not be a wise investment in this market. Threats of competition are severe, especially from depreciated vessels that could significantly undercut newer vessel rates. Short- and medium-term charters would be ideal for vessel operators.

The American tradition of operating vessels longer than international norms makes long-term production statistics particularly relevant in analyzing future vessel demands in the TAPS trades. A vessel delivered in 2010 would most likely be expected to be operating until 2040 or later, beyond the scope of the Energy Information Administration's production estimates. Extrapolating production trends beyond this time

horizon may be appealing but uncertainties compound the problem. Investors must therefore be confident in production estimates before embarking on any newbuilding program.

All three production estimates- 5% probability, mean, and 95% probability- give the same values of estimated production through 2004. However, the production estimates that have been made for 2001 through 2003 with the same techniques as for future years have yielded much greater estimates of production than was actually achieved. Actual production values and estimates are given in Table 8.

Year	Estimated Production (bbl)	Actual Production (bbl)
2001	388,944,000	355,000,000
2002	386,827,000	361,000,000
2003	387,354,500	357,000,000

Table 8: Estimated and actual Alaskan crude production, 2001 through 2003. (Energy Information Administration)

As can be seen from Table 8, production estimates have consistently been more optimistic than actual production figures by approximately eight percent. Although only a small percentage, such would account for several vessels' entire contribution to the TAPS trade. Ambitious production increases will take several years to accomplish, so the accuracy of production estimates in comparison to actual production figures must be remembered by vessel operators considering expansion of their TAPS fleet.

CONCLUSIONS

The introduction of this work began with a summary of the importance of the Trans-Alaskan Pipeline System trade to American energy needs and the maritime industry, and this theme has recurred throughout. However, the story of its growth, and a look at its current state, reveals the true complexity of the technical, financial, and political forces that will shape its future. The TAPS trade has not had an easy life, and a quick look at the aged vessels and high operating costs does little to improve its ever-marred reputation in a post-Exxon Valdez world.

The Oil Pollution Act of 1990, a death sentence for many of the 'old ways' of the tanker industry, gives promise of a rebirth for the TAPS fleet. Mandatory phase-out of old (though expensive) tonnage has shown to be one of the few effective ways for renewal within the Jones Act fleet. Initiatives by prominent players such as BP have raised standards for newbuildings. Operating standards worldwide have also been raised, which will contribute in regaining confidence from the general public of the safety and importance of all tankers.

The new tanker environment has come at a cost, however. Capital costs remain very high for new vessels, and American shipyards do not have the experience or the efficiency to produce quality tonnage at economical prices. Gray shipyards that have experimented with commercial tanker building have often been so unsuccessful that they have no initiative to enter the market again. However, the threat of strong new entrants, including Kvaerner Philadelphia Shipyard and Bollinger Shipyards, may give the industry needed suppliers willing to invest in the training and technology needed to meet TAPS needs. Additionally, the threat of stronger government monitoring of naval ship

construction programs may provide the catalyst for other shipyards to make needed improvements and investments in order to preserve that central source of business. That efficiency may also become manifest, in time, in those shipyards' commercial capabilities.

The future of the TAPS trade is dependent upon the long-term viability of North Slope oil production. Although production estimates show that this will remain an important trade throughout the first half of the 21st century, fleet investment needs will vary significantly depending upon actual production. From 2001 through 2003 production estimates overestimated actual production, so close scrutiny by tanker operators is needed before proceeding with any investment. The recent legislative action permitting the opening of the Alaskan National Wildlife Reserve to future development will ensure to long-term viability of the trade, but close monitoring of political forces is needed to understand the true implications of this decision.

The overall outlook for the TAPS trade is neither decidedly positive nor negative. Opportunities exist for new vessels and new players, but barriers to entry are very high. Exit barriers are also high, as versatility among vessels is difficult to achieve, particularly for crude carriers, which have few other opportunities in Jones Act trades. A market will exist for many years to come, but estimates of its size vary greatly, and political pressures add more uncertainty to the long-term outlook. Capital costs for new tonnage remain high, but large investments may make purchases economical. However, it is unclear whether the trade could absorb the amount of tonnage necessary to achieve economical per-vessel prices.

It is an exciting time for the TAPS trade, as its future prospects are becoming clearer week by week. The recent commitment by Kvaerner Philadelphia Shipyard and OSG to produce ten 46,000 DWT MT-46 class product tankers may have significant implications for the future of the TAPS trade. Adding vessels to Alaskan service may provide needed capacity but the scope of the proposed construction program may prove too daunting for the young Philadelphia shipyard absorbing the $1 billion capital cost.

The TAPS trade is relatively unaffected by international tanker cycles but many of the lessons learned in the international trade can be applied to this niche market. Reinvestment is needed periodically to revive the trade, but overinvestment will benefit no one. Market equilibrium is hard to reach in a dynamic market. A strong, viable future in the TAPS trade can only be achieved by market players through wise investment, sound business strategy, and a little bit of good luck.

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APPENDIX A

POST-WWII U.S. TANKER BUILDINGS

Figure 8 illustrates the number and tonnages of tankers constructed in U.S. shipyards by years. The vessels represented are still trading as of 1 May 2005. Details of the vessels are given in Table 6.

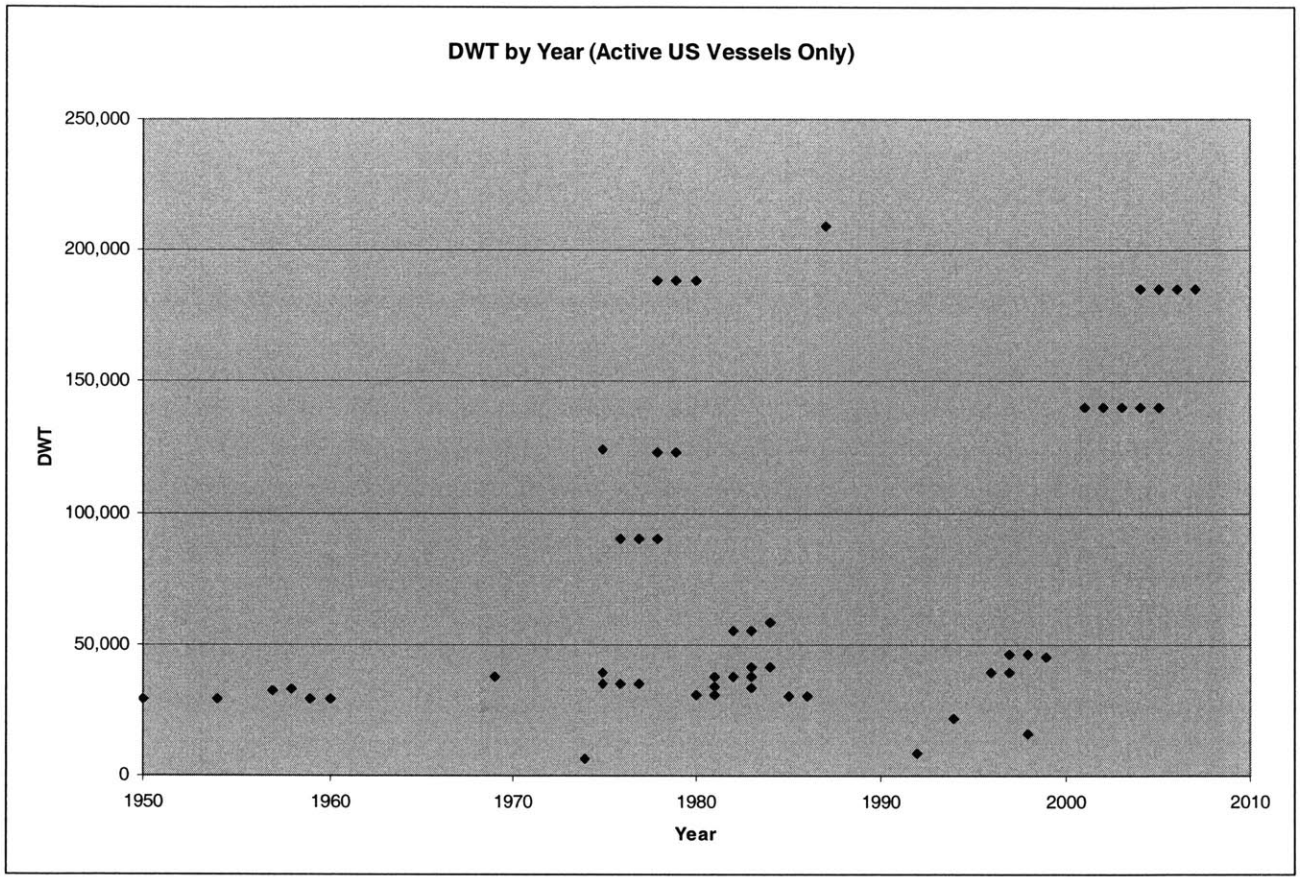

Figure 8: U.S. tanker buildings and tonnages by year. Active vessels only. (Maritime Business Strategies , U.S. Flag Tanker Statistics)

Year	Original Name	Ship Type	DWT	Price ($mm)	Notes
1950	Esso New York	Tanker	29,000		Now "Falcon Duchess"
1954	W. Alton Jones	Tanker	29,000		Now "Ocean Clipper"
1957	Gulfking	Tanker	32,600		Now "Captain H. A. Downing"
1958	Gulfknight	Tanker	32,900		Now "Anasazi"
1959	Gulfsolar	Tanker	29,200		Now "The Monseigneur"
1960	Gulfspray	Tanker	29,200		Now "New River"
1969	Ogden Willamette	Product Carrier	37,800	11.3	Now "Seabulk Power"
1974	Saturn	Product Carrier	6,500		Active
1975	Prince William Sound	Crude Carrier	124,000	70	Active
1975	Chevron Oregon	Product Carrier	35,000	16.7	Now "Diligence"
1975	Chelsea	Product Carrier	39,237	18.2	Now owned by Keystone Shipping
1976	Beaver State	Crude Carrier	90,000	28.2	Laid up
1976	Chevron Colorado	Product Carrier	35,000	16.7	Now "Colorado Voyager"
1976	Chevron Washington	Product Carrier	35,000	16.7	Now "Washington Voyager"
1977	Overseas Chicago	Crude Carrier	90,000	29.9	Active
1977	Overseas New York	Crude Carrier	90,000	29.9	Active
1977	Chevron Arizona	Product Carrier	35,000	16.7	Now "Arizona Voyager"
1977	Chevron Louisiana	Product Carrier	35,000	16.7	Now "Integrity"
1977	Overseas Ohio	Crude Carrier	90,000	29.9	Now "S/R Hinchinbrook"
1978	Overseas Washington	Crude Carrier	90,000	29.9	Active
1978	B.T. San Diego	Crude Carrier	188,500	67	Now "Denali"
1978	B.T. Alaska	Crude Carrier	188,500	67	Now "S/R

					Columbia Bay"
1978	Tonsina	Crude Carrier	123,000	70	Sold to SeaRiver 2005, active
1979	Arco Alaska	Crude Carrier	188,500	60	Now "Polar Alaska"
1979	Kenai	Crude Carrier	123,000	70	Sold to SeaRiver 2005, active
1980	New York Sun	Product Carrier	31,000	36	Now "Allegiance"
1980	Arco California	Crude Carrier	188,500	60	Now "Polar California"
1981	Sierra Madre	Product Carrier	37,500	50	Now "Keystone Texas"
1981	Philadelphia Sun	Product Carrier	31,000	36	Now "Perseverance"
1981	Oxy 4101	Chemical Carrier	34,000	54.7	Now "SMT Chemical Explorer"
1981	Oxy 4103	Chemical Carrier	34,000	54.7	Now "SMT Chemical Trader"
1981	Blue Ridge	Product Carrier	37,500	50	Now owned by Crowley
1981	Coast Range	Product Carrier	37,500	50	Now owned by Crowley
1982	Eileen Ingram	Product Carrier	37,500	50	Now "Overseas New Orleans"
1982	Delaware Trader	Crude Carrier	55,000	65.7	Now "Polar Trader"
1982	Chesapeake Trader	Crude Carrier	55,000	65.7	Now "S/R Galena Bay"
1983	Exxon Charleston	Product Carrier	41,650	100	Now "Charleston"
1983	Hunter B. Armistead	Product Carrier	37,500	50	Now "Overseas Philadelphia"
1983	Potomac Trader	Crude Carrier	55,000	65.7	Now "S/R Puget Sound"
1983	Falcon Leader	Product Carrier	33,600	71	Now "Sabine Eagle"
1984	Exxon Baytown	Crude Carrier	58,300	100	Renamed "S/R

					Baytown"
1984	Exxon Wilmington	Product Carrier	41,650	100	Renamed "S/R Wilmington"
1985	Gus W. Darnell	Product Carrier	30,000	52	Active
1985	Paul Buck	Product Carrier	30,000	52	Active
1986	Samuel L. Cobb	Product Carrier	30,000	60	Active
1986	Richard G. Matthiesen	Product Carrier	30,000	60	Active
1986	Lawrence H. Gianella	Product Carrier	30,000	60	Active
1987	Exxon Long Beach	Crude Carrier	209,000	125	Now "S/R Long Beach"
1992	Benno C. Schmidt	Sulphur Carrier	8,318	13	Active
1992	W.K.McWilliams,Jr.	Sulphur Carrier	8,318	13	Now "Energy Service 9001"
1994	Sulphur Enterprise	Sulphur Carrier	21,649	58.5	Active
1996	Captain Downing	Product Carrier	39,400	39.8	Active
1997	Anasazi	Product Carrier	39,400	39.8	Active
1997	New River	Product Carrier	39,400	39.8	Active
1997	The Monseigneur	Product Carrier	39,400	39.8	Active
1997	Despotico	Product Carrier	46,100	38	Now "S/R American Progress"
1998	Amalienborg	Chemical Carrier	16,000	26	Active
1998	Aggersborg	Chemical Carrier	16,000	26	Active
1998	Dhokos	Product Carrier	46,100	38	Now "Seabulk Arctic"
1998	Makronissos	Product Carrier	46,100	39	Now "Seabulk Mariner"
1998	Agathonissos	Product Carrier	46,100	38	Now "Seabulk Pride"
1999	HMI Ambrose Channel	Product Carrier	45,300	49.4	Now "Seabulk Energy"
1999	HMI Brenton Reef	Product Carrier	45,300	49.4	Now "Seabulk Marketer"

2001	Polar Endeavour	Crude Carrier	140,000	166	Active
2002	Polar Resolution	Crude Carrier	140,000	166	Active
2003	Polar Discovery	Crude Carrier	140,000	164	Active
2004	Polar Adventure	Crude Carrier	140,000	196	Active
2004	Alaskan Frontier	Crude Carrier	185,000	210	Active
2005	Alaskan Explorer	Crude Carrier	185,000	210	Active
2005	Polar Enterprise	Crude Carrier	140,000	205.5	Under construction
2006	Alaskan Adventurer	Crude Carrier	185,000	210	Under Construction
2007	Alaskan Legend	Crude Carrier	185,000	210	Under Construction

Table 9: Details of active U.S. tankers. (Maritime Business Strategies, U.S. Flag Tanker Statistics)

APPENDIX B

DETAILS OF NEW BP TANKERS

Details of new BP tankers constructed by NASSCO are as follows:

- LOA: 287.25m
- Beam: 50.00m
- Depth: 28.00m
- Design draft: 18.75m
- Speed at 85% MCR: 15.3 kts
- Cargo capacity (98%): 1,300,000 bbls
- Design deadweight: 185,000 t
- Design displacement: 220, 966 t
- Lightship weight: approx. 35,950 t (NASSCO 1)

Unique design features include:

- 2.7m double hull spacing, significantly larger from the 2m standard
- Two high-efficiency, fully hung spade-type rudders
- Twin-screw diesel-electric propulsion with total propulsive power of 20.0 MW
- 4 main engines (each MAN B&W 6L48/60, 6.3 MW, total installed power 25.2 MW @ 512 RPM)

The new vessels are classed ABS to the following specifications:

✠A1Ⓔ "Oil Carrier" ✠AMS ACCU, NIBS, DLA, SH, COW, IGS, SBT, HM2+R, VEC-L, UWILD

DETAILS OF NEW KVAERNER MT-46 VETERAN CLASS TANKERS

Details of new Veteran Class tankers to be constructed by Kvaerner Philadelphia Shipyard are as follows:

- Length: 183m
- Beam 32.2m (Panamax)
- Power: 11,600 hp (single diesel engine)
- Speed: 15 kts
- Tanks: 12 (52,650 m^3 capacity)
- Discharge: 12 hours
- Crew: 26 persons
- Designer: Hyundai Mipo Dockyard

APPENDIX C

DETAILS OF ALYESKA MARINE TERMINAL

Restrictions dictated by Valdez terminal limit vessels to (Alyeska 1):

- Draft restrictions (mean low water)
    - Berth 1 (floating): 110 ft
    - Berths 3 and 4 (fixed): 90 ft
    - Berth 5 (fixed): 80 ft
- Load rate: 80,000-100,000 bbl/hr
- Holding tanks: 9.18 million bbl, total
- Ballast water treatment
    - 30,000 bbl/hr
    - Crude recovered from ballast: 800 bbl/day (avg)

APPENDIX D

DETAILS OF JONES ACT CLEAN FLEET

Details of the Jones Act product and chemical tanker fleet are given below in Table 7.

Owner/Operator	Vessel Name	Hull Type	Year Built/Rebuilt	OPA90 Phase Out Date	DWT (000)
ChevronTexaco Shipping	Colorado Voyager	DH	1976		40
ChevronTexaco Shipping	Washington Voyager	DH	1976		40
ChevronTexaco Shipping	Arizona Voyager	DH	1977		40
Keystone Shipping	Keystone Texas	DB	1981	18-Dec-11	41
Maritime Overseas	Overseas New Orleans	DB	1983	30-Jun-13	44
Maritime Overseas	Overseas Philadelphia	DB	1982	21-May-12	44
Maritrans	Allegiance	SH	1980	5-Dec-05	35
Maritrans	Perseverance	SH	1981	17-Jul-06	35
Maritrans	Diligence	DH	1975		40
Maritrans	Integrity	DH	1975		40
Ocean Ships	Gus W. Darnell	DH	1986		31
Ocean Ships	Lawrence H. Gianella	DH	1986		31
Ocean Ships	Paul Buck	DH	1986		31
Ocean Ships	Richard G. Matthiesen	DH	1986		31
Ocean Ships	Samuel L. Cobb	DH	1986		31
Polar Tankers	Polar Trader	DB	1982	17-Dec-12	51
Sabine Tankships	Sabine Eagle	SH	1983	7-Aug-08	34
Seabulk Tankers	Seabulk Power	SH	1983	01-Jan-08	38
SeaRiver Maritime	S/R Galena Bay	DB	1982	6-Oct-12	51
SeaRiver Maritime	S/R Baytown	DB	1984	15-Jul-14	59
SeaRiver Maritime	S/R Puget Sound	DB	1983	10-May-13	51

SeaRiver Maritime	S/R Wilmington	DB	1984	15-Apr-14	49
U.S. Shipping	Groton (ITB)	DB	1982	15-Feb-12	46
U.S. Shipping	Jacksonville (ITB)	DB	1982	15-Jan-12	46
U.S. Shipping	Baltimore (ITB)	DB	1983	5-May-13	46
U.S. Shipping	New York (ITB)	DB	1983	3-Feb-13	46
U.S. Shipping	Mobile (ITB)	DB	1984	12-Jun-14	46
U.S. Shipping	Philadelphia (ITB)	DB	1984	15-Apr-14	46
Vessel Management Services	Blue Ridge	DB	1981	27-Jun-11	42
Vessel Management Services	Coast Range	DB	1981	29-Sep-11	41
Total (30 ships)					1246
Post-OPA90 Newbuildings					
American Heavy Lift	Captain H.A. Downing	DH	1996		40
American Heavy Lift	Anasazi	DH	1997		40
American Heavy Lift	New River	DH	1997		39
American Heavy Lift	The Monseigneur	DH	1997		39
SeaRiver Maritime	S/R American Progress	DH	1997		41
Seabulk Tankers	Seabulk Pride	DH	1998		46
Seabulk Tankers	Seabulk Arctic	DH	1998		46
Seabulk Tankers	Seabulk Mariner	DH	1998		46
Seabulk Tankers	Seabulk Energy	DH	1999		45
Seabulk Tankers	Seabulk Marketer	DH	1999		45
Total (10 ships)					427

Total US-Built Product Carrier Fleet (41 ships)					1,673
Foreign-Built Flagged-In Fleet					
Maersk Line Ltd.	Maersk Rhode Island	DH	2002	Maersk Line Ltd.	35
Overseas Shipholding	Maersk Rapier	DH	2000	Overseas Shipholding	35
Overseas Shipholding	Maersk Regent	DH	2003	Overseas Shipholding	35
Overseas Shipholding	Maersk Richmond	DH	2003	Overseas Shipholding	35
Total Foreign-Built Product Carrier Fleet (4 ships)					140
Total US-Flag Product Carrier Fleet (45 ships)					1,813
Chemical Carrier Fleet					
Atlantic Tankships	Sea Venture	DB	1983		19
Central Gulf Line	Sulphur Enterprise	DH	1994		27
Freeport McMoran	Benno C. Schmidt	DH	1992		8
Hornbeck Offshore Services	Energy Service 9001	DH	1992		8
K-Sea Transportation	DBL 105 (ITB)	DB	1982		16
Sargeant Marine	Asphalt Commander	SH	1984		34
Seabulk Tankers	Seabulk America	DB	1990		47
Seabulk Tankers	Seabulk Magnachem (ITB)	DB	1977		40
Seabulk Tankers	Seabulk Trader	DB	1981		52
Seabulk Tankers	Seabulk Challenge	DB	1981		52

U.S. Chemical Shipping	Charleston	DB	1983		49
U.S. Chemical Shipping	Chemical Pioneer	DB	1983		35
Vessel Management Services	SMT One (ITB)	DB	1981		41
Vessel Management Services	SMT Two (ITB)	DB	1981		41
Total US-Flag Chemical Carrier Fleet (13 ships)					469
Total US-Flag Product and Chemical Carrier Fleet (58 ships)					2,282

Table 10: Details of Jones Act Product and Chemical Tanker Fleet. (Maritime Business Strategies U.S. Flag Clean Fleet)

APPENDIX E

ANALYSIS OF REQUIRED CAPACITY CONSIDERING PRODUCTION ESTIMATES

Tables 11, 12, and 13 show calculations of annual vessel capacity, in bbl, for incremental increases in fleet size of *n* MT-46 product tankers. Surplus and (deficit) capacities are shown for 95% probability, mean, and 5% probability production estimates based on Energy Information Administration data.

95% Probability Production Estimates

Assumptions

Vessel load factor:	100%
Cargo density:	6.7686
Voyages/vessel/year:	25
Kvaerner Tanker capacity:	326,640 bbls

	Production (bbls/year)	Capacity w/ Kværner Vessels Added, Capacity Differential (bbl)																			
Year	95% Probability	0		1		2		3		4		5		6		7		8		9		10	
2001	388,944,000	491,556,330	102,612,330	499,722,330	110,778,330	507,888,330	118,944,330	516,054,330	127,110,330	524,220,330	135,276,330	532,386,330	143,442,330	540,552,330	151,608,330	548,718,330	159,774,330	556,884,330	167,940,330	565,050,330	176,106,330	573,216,330	184,272,330
2002	386,827,000	491,556,330	104,729,330	499,722,330	112,895,330	507,888,330	121,061,330	516,054,330	129,227,330	524,220,330	137,393,330	532,386,330	145,559,330	540,552,330	153,725,330	548,718,330	161,891,330	556,884,330	170,057,330	565,050,330	178,223,330	573,216,330	186,389,330
2003	387,374,500	491,556,330	104,181,830	499,722,330	112,347,830	507,888,330	120,513,830	516,054,330	128,679,830	524,220,330	136,845,830	532,386,330	145,011,830	540,552,330	153,177,830	548,718,330	161,343,830	556,884,330	169,509,830	565,050,330	177,675,830	573,216,330	185,841,830
2004	396,390,000	491,556,330	95,166,330	499,722,330	103,332,330	507,888,330	111,498,330	516,054,330	119,664,330	524,220,330	127,830,330	532,386,330	135,996,330	540,552,330	144,162,330	548,718,330	152,328,330	556,884,330	160,494,330	565,050,330	168,660,330	573,216,330	176,826,330
2005	390,002,500	491,556,330	101,553,830	499,722,330	109,719,830	507,888,330	117,885,830	516,054,330	126,051,830	524,220,330	134,217,830	532,386,330	142,383,830	540,552,330	150,549,830	548,718,330	158,715,830	556,884,330	166,881,830	565,050,330	175,047,830	573,216,330	183,213,830
2006	368,650,000	442,569,094	73,919,094	450,735,094	82,085,094	458,901,094	90,251,094	467,067,094	98,417,094	475,233,094	106,583,094	483,399,094	114,749,094	491,565,094	122,915,094	499,731,094	131,081,094	507,897,094	139,247,094	516,063,094	147,413,094	524,229,094	155,579,094
2007	345,290,000	348,471,336	3,181,336	356,637,336	11,347,336	364,803,336	19,513,336	372,969,336	27,679,336	381,135,336	35,845,336	389,301,336	44,011,336	397,467,336	52,177,336	405,633,336	60,343,336	413,799,336	68,509,336	421,965,336	76,675,336	430,131,336	84,841,336
2008	318,535,500	326,281,326	7,745,826	334,447,326	15,911,826	342,613,326	24,077,826	350,779,326	32,243,826	358,945,326	40,409,826	367,111,326	48,575,826	375,277,326	56,741,826	383,443,326	64,907,826	391,609,326	73,073,826	399,775,326	81,239,826	407,941,326	89,405,826
2009	292,292,000	304,091,316	11,799,316	312,257,316	19,965,316	320,423,316	28,131,316	328,589,316	36,297,316	336,755,316	44,463,316	344,921,316	52,629,316	353,087,316	60,795,316	361,253,316	68,961,316	369,419,316	77,127,316	377,585,316	85,293,316	385,751,316	93,459,316
2010	270,939,500	304,091,316	33,151,816	312,257,316	41,317,816	320,423,316	49,483,816	328,589,316	57,649,816	336,755,316	65,815,816	344,921,316	73,981,816	353,087,316	82,147,816	361,253,316	90,313,816	369,419,316	98,479,816	377,585,316	106,645,816	385,751,316	114,811,816
2011	254,879,500	281,901,306	27,021,806	290,067,306	35,187,806	298,233,306	43,353,806	306,399,306	51,519,806	314,565,306	59,685,806	322,731,306	67,851,806	330,897,306	76,017,806	339,063,306	84,183,806	347,229,306	92,349,806	355,395,306	100,515,806	363,561,306	108,681,806
2012	241,703,000	281,901,306	40,198,306	290,067,306	48,364,306	298,233,306	56,530,306	306,399,306	64,696,306	314,565,306	72,862,306	322,731,306	81,028,306	330,897,306	89,194,306	339,063,306	97,360,306	347,229,306	105,526,306	355,395,306	113,692,306	363,561,306	121,858,306
2013	229,694,500	281,901,306	52,206,806	290,067,306	60,372,806	298,233,306	68,538,806	306,399,306	76,704,806	314,565,306	84,870,806	322,731,306	93,036,806	330,897,306	101,202,806	339,063,306	109,368,806	347,229,306	117,534,806	355,395,306	125,700,806	363,561,306	133,866,806
2014	218,708,000	281,901,306	63,193,306	290,067,306	71,359,306	298,233,306	79,525,306	306,399,306	87,691,306	314,565,306	95,857,306	322,731,306	104,023,306	330,897,306	112,189,306	339,063,306	120,355,306	347,229,306	128,521,306	355,395,306	136,687,306	363,561,306	144,853,306
2015	210,532,000	281,901,306	71,369,306	290,067,306	79,535,306	298,233,306	87,701,306	306,399,306	95,867,306	314,565,306	104,033,306	322,731,306	112,199,306	330,897,306	120,365,306	339,063,306	128,531,306	347,229,306	136,697,306	355,395,306	144,863,306	363,561,306	153,029,306
2016	203,962,000	281,901,306	77,939,306	290,067,306	86,105,306	298,233,306	94,271,306	306,399,306	102,437,306	314,565,306	110,603,306	322,731,306	118,769,306	330,897,306	126,935,306	339,063,306	135,101,306	347,229,306	143,267,306	355,395,306	151,433,306	363,561,306	159,599,306
2017	191,515,500	281,901,483	90,385,983	290,067,483	98,551,983	298,233,483	106,717,983	306,399,483	114,883,983	314,565,483	123,049,983	322,731,483	131,215,983	330,897,483	139,381,983	339,063,483	147,547,983	347,229,483	155,713,983	355,395,483	163,879,983	363,561,483	172,045,983
2018	176,185,500	281,901,661	105,716,161	290,067,661	113,882,161	298,233,661	122,048,161	306,399,661	130,214,161	314,565,661	138,380,161	322,731,661	146,546,161	330,897,661	154,712,161	339,063,661	162,878,161	347,229,661	171,044,161	355,395,661	179,210,161	363,561,661	187,376,161
2019	160,819,000	281,901,838	121,082,838	290,067,838	129,248,838	298,233,838	137,414,838	306,399,838	145,580,838	314,565,838	153,746,838	322,731,838	161,912,838	330,897,838	170,078,838	339,063,838	178,244,838	347,229,838	186,410,838	355,395,838	194,576,838	363,561,838	202,742,838
2020	146,803,000	281,902,016	135,099,016	290,068,016	143,265,016	298,234,016	151,431,016	306,400,016	159,597,016	314,566,016	167,763,016	322,732,016	175,929,016	330,898,016	184,095,016	339,064,016	192,261,016	347,230,016	200,427,016	355,396,016	208,593,016	363,562,016	216,759,016
2021	134,101,000	281,902,193	147,801,193	290,068,193	155,967,193	298,234,193	164,133,193	306,400,193	172,299,193	314,566,193	180,465,193	322,732,193	188,631,193	330,898,193	196,797,193	339,064,193	204,963,193	347,230,193	213,129,193	355,396,193	221,295,193	363,562,193	229,461,193
2022	122,822,500	281,902,371	159,079,871	290,068,371	167,245,871	298,234,371	175,411,871	306,400,371	183,577,871	314,566,371	191,743,871	322,732,371	199,909,871	330,898,371	208,075,871	339,064,371	216,241,871	347,230,371	224,407,871	355,396,371	232,573,871	363,562,371	240,739,871
2023	112,237,500	281,902,548	169,665,048	290,068,548	177,831,048	298,234,548	185,997,048	306,400,548	194,163,048	314,566,548	202,329,048	322,732,548	210,495,048	330,898,548	218,661,048	339,064,548	226,827,048	347,230,548	234,993,048	355,396,548	243,159,048	363,562,548	251,325,048
2024	102,601,500	281,902,726	179,301,226	290,068,726	187,467,226	298,234,726	195,633,226	306,400,726	203,799,226	314,566,726	211,965,226	322,732,726	220,131,226	330,898,726	228,297,226	339,064,726	236,463,226	347,230,726	244,629,226	355,396,726	252,795,226	363,562,726	260,961,226
2025	93,805,000	281,902,903	188,097,903	290,068,903	196,263,903	298,234,903	204,429,903	306,400,903	212,595,903	314,566,903	220,761,903	322,732,903	228,927,903	330,898,903	237,093,903	339,064,903	245,259,903	347,230,903	253,425,903	355,396,903	261,591,903	363,562,903	269,757,903
2026	85,519,500	281,903,081	196,383,581	290,069,081	204,549,581	298,235,081	212,715,581	306,401,081	220,881,581	314,567,081	229,047,581	322,733,081	237,213,581	330,899,081	245,379,581	339,065,081	253,545,581	347,231,081	261,711,581	355,397,081	269,877,581	363,563,081	278,043,581
2027	78,000,500	281,903,258	203,902,758	290,069,258	212,068,758	298,235,258	220,234,758	306,401,258	228,400,758	314,567,258	236,566,758	322,733,258	244,732,758	330,899,258	252,898,758	339,065,258	261,064,758	347,231,258	269,230,758	355,397,258	277,396,758	363,563,258	285,562,758
2028	71,138,500	281,903,436	210,764,936	290,069,436	218,930,936	298,235,436	227,096,936	306,401,436	235,262,936	314,567,436	243,428,936	322,733,436	251,594,936	330,899,436	259,760,936	339,065,436	267,926,936	347,231,436	276,092,936	355,397,436	284,258,936	363,563,436	292,424,936
2029	64,860,500	281,903,613	217,043,113	290,069,613	225,209,113	298,235,613	233,375,113	306,401,613	241,541,113	314,567,613	249,707,113	322,733,613	257,873,113	330,899,613	266,039,113	339,065,613	274,205,113	347,231,613	282,371,113	355,397,613	290,537,113	363,563,613	298,703,113
2030	59,130,000	281,903,791	222,773,791	290,069,791	230,939,791	298,235,791	239,105,791	306,401,791	247,271,791	314,567,791	255,437,791	322,733,791	263,603,791	330,899,791	271,769,791	339,065,791	279,935,791	347,231,791	288,101,791	355,397,791	296,267,791	363,563,791	304,433,791
2031	53,618,500	281,903,968	228,285,468	290,069,968	236,451,468	298,235,968	244,617,468	306,401,968	252,783,468	314,567,968	260,949,468	322,733,968	269,115,468	330,899,968	277,281,468	339,065,968	285,447,468	347,231,968	293,613,468	355,397,968	301,779,468	363,563,968	309,945,468
2032	48,180,000	281,904,146	233,724,146	290,070,146	241,890,146	298,236,146	250,056,146	306,402,146	258,222,146	314,568,146	266,388,146	322,734,146	274,554,146	330,900,146	282,720,146	339,066,146	290,886,146	347,232,146	299,052,146	355,398,146	307,218,146	363,564,146	315,384,146
2033	43,179,500	281,904,323	238,724,823	290,070,323	246,890,823	298,236,323	255,056,823	306,402,323	263,222,823	314,568,323	271,388,823	322,734,323	279,554,823	330,900,323	287,720,823	339,066,323	295,886,823	347,232,323	304,052,823	355,398,323	312,218,823	363,564,323	320,384,823
2034	38,653,500	281,904,501	243,251,001	290,070,501	251,417,001	298,236,501	259,583,001	306,402,501	267,749,001	314,568,501	275,915,001	322,734,501	284,081,001	330,900,501	292,247,001	339,066,501	300,413,001	347,232,501	308,579,001	355,398,501	316,745,001	363,564,501	324,911,001
2035	35,587,500	281,904,678	246,317,178	290,070,678	254,483,178	298,236,678	262,649,178	306,402,678	270,815,178	314,568,678	278,981,178	322,734,678	287,147,178	330,900,678	295,313,178	339,066,678	303,479,178	347,232,678	311,645,178	355,398,678	319,811,178	363,564,678	327,977,178
2036	31,463,000	281,904,856	250,441,856	290,070,856	258,607,856	298,236,856	266,773,856	306,402,856	274,939,856	314,568,856	283,105,856	322,734,856	291,271,856	330,900,856	299,437,856	339,066,856	307,603,856	347,232,856	315,769,856	355,398,856	323,935,856	363,564,856	332,101,856
2037	28,944,500	281,905,034	252,960,534	290,071,034	261,126,534	298,237,034	269,292,534	306,403,034	277,458,534	314,569,034	285,624,534	322,735,034	293,790,534	330,901,034	301,956,534	339,067,034	310,122,534	347,233,034	318,288,534	355,399,034	326,454,534	363,565,034	334,620,534
2038	26,608,500	281,905,211	255,296,711	290,071,211	263,462,711	298,237,211	271,628,711	306,403,211	279,794,711	314,569,211	287,960,711	322,735,211	296,126,711	330,901,211	304,292,711	339,067,211	312,458,711	347,233,211	320,624,711	355,399,211	328,790,711	363,565,211	336,956,711
2039	24,491,500	281,905,389	257,413,889	290,071,389	265,579,889	298,237,389	273,745,889	306,403,389	281,911,889	314,569,389	290,077,889	322,735,389	298,243,889	330,901,389	306,409,889	339,067,389	314,575,889	347,233,389	322,741,889	355,399,389	330,907,889	363,565,389	339,073,889

Table 11: Fleet capacity with incremental vessel additions and annual vessel space surplus (deficit) considering 95% probability production estimates.

Mean Production Estimates

Assumptions

Vessel load factor:	100%
Cargo density:	6.7686
Voyages/vessel/year:	25
Kvaerner Tanker capacity:	326,640 bbls

Production (bbls/year) Capacity w/ Kværner Vessels Added, Capacity Differential (bbl)

Required Vessel Delivery Rate

Year	Mean Cases	0		1		2		3		4		5		6		7		8		9		10	
2001	388,944,000	491,556,330	102,612,330	499,722,330	110,778,330	507,888,330	118,944,330	516,054,330	127,110,330	524,220,330	135,276,330	532,386,330	143,442,330	540,552,330	151,608,330	548,718,330	159,774,330	556,884,330	167,940,330	565,050,330	176,106,330	573,216,330	184,272,330
2002	386,827,000	491,556,330	104,729,330	499,722,330	112,895,330	507,888,330	121,061,330	516,054,330	129,227,330	524,220,330	137,393,330	532,386,330	145,559,330	540,552,330	153,725,330	548,718,330	161,891,330	556,884,330	170,057,330	565,050,330	178,223,330	573,216,330	186,389,330
2003	387,374,500	491,556,330	104,181,830	499,722,330	112,347,830	507,888,330	120,513,830	516,054,330	128,679,830	524,220,330	136,845,830	532,386,330	145,011,830	540,552,330	153,177,830	548,718,330	161,343,830	556,884,330	169,509,830	565,050,330	177,675,830	573,216,330	185,841,830
2004	396,390,000	491,556,330	95,166,330	499,722,330	103,332,330	507,888,330	111,498,330	516,054,330	119,664,330	524,220,330	127,830,330	532,386,330	135,996,330	540,552,330	144,162,330	548,718,330	152,328,330	556,884,330	160,494,330	565,050,330	168,660,330	573,216,330	176,826,330
2005	395,477,500	491,556,330	96,078,830	499,722,330	104,244,830	507,888,330	112,410,830	516,054,330	120,576,830	524,220,330	128,742,830	532,386,330	136,908,830	540,552,330	145,074,830	548,718,330	153,240,830	556,884,330	161,406,830	565,050,330	169,572,830	573,216,330	177,738,830
2006	385,075,000	442,569,094	57,494,094	450,735,094	65,660,094	458,901,094	73,826,094	467,067,094	81,992,094	475,233,094	90,158,094	483,399,094	98,324,094	491,565,094	106,490,094	499,731,094	114,656,094	507,897,094	122,822,094	516,063,094	130,988,094	524,229,094	139,154,094
2007	376,315,000	348,471,336	(27,843,664)	356,637,336	(19,677,664)	364,803,336	(11,511,664)	372,969,336	(3,345,664)	381,135,336	4,820,336	389,301,336	12,986,336	397,467,336	21,152,336	405,633,336	29,318,336	413,799,336	37,484,336	421,965,336	45,650,336	430,131,336	53,816,336
2008	367,117,000	326,281,326	(40,835,674)	334,447,326	(32,669,674)	342,613,326	(24,503,674)	350,779,326	(16,337,674)	358,945,326	(8,171,674)	367,111,326	(5,674)	375,277,326	8,160,326	383,443,326	16,326,326	391,609,326	24,492,326	399,775,326	32,658,326	407,941,326	40,824,326
2009	356,751,000	304,091,316	(52,659,684)	312,257,316	(44,493,684)	320,423,316	(36,327,684)	328,589,316	(28,161,684)	336,755,316	(19,995,684)	344,921,316	(11,829,684)	353,087,316	(3,663,684)	361,253,316	4,502,316	369,419,316	12,668,316	377,585,316	20,834,316	385,751,316	29,000,316
2010	350,692,000	304,091,316	(46,600,684)	312,257,316	(38,434,684)	320,423,316	(30,268,684)	328,589,316	(22,102,684)	336,755,316	(13,936,684)	344,921,316	(5,770,684)	353,087,316	2,395,316	361,253,316	10,561,316	369,419,316	18,727,316	377,585,316	26,893,316	385,751,316	35,059,316
2011	349,451,000	281,901,306	(67,549,694)	290,067,306	(59,383,694)	298,233,306	(51,217,694)	306,399,306	(43,051,694)	314,565,306	(34,885,694)	322,731,306	(26,719,694)	330,897,306	(18,553,694)	339,063,306	(10,387,694)	347,229,306	(2,221,694)	355,395,306	5,944,306	363,561,306	14,110,306
2012	352,809,000	281,901,306	(70,907,694)	290,067,306	(62,741,694)	298,233,306	(54,575,694)	306,399,306	(46,409,694)	314,565,306	(38,243,694)	322,731,306	(30,077,694)	330,897,306	(21,911,694)	339,063,306	(13,745,694)	347,229,306	(5,579,694)	355,395,306	2,586,306	363,561,306	10,752,306
2013	346,604,000	281,901,306	(64,702,694)	290,067,306	(56,536,694)	298,233,306	(48,370,694)	306,399,306	(40,204,694)	314,565,306	(32,038,694)	322,731,306	(23,872,694)	330,897,306	(15,706,694)	339,063,306	(7,540,694)	347,229,306	625,306	355,395,306	8,791,306	363,561,306	16,957,306
2014	334,559,000	281,901,306	(52,657,694)	290,067,306	(44,491,694)	298,233,306	(36,325,694)	306,399,306	(28,159,694)	314,565,306	(19,993,694)	322,731,306	(11,827,694)	330,897,306	(3,661,694)	339,063,306	4,504,306	347,229,306	12,670,306	355,395,306	20,836,306	363,561,306	29,002,306
2015	324,010,500	281,901,306	(42,109,194)	290,067,306	(33,943,194)	298,233,306	(25,777,194)	306,399,306	(17,611,194)	314,565,306	(9,445,194)	322,731,306	(1,279,194)	330,897,306	6,886,806	339,063,306	15,052,806	347,229,306	23,218,806	355,395,306	31,384,806	363,561,306	39,550,806
2016	316,710,500	281,901,306	(34,809,194)	290,067,306	(26,643,194)	298,233,306	(18,477,194)	306,399,306	(10,311,194)	314,565,306	(2,145,194)	322,731,306	6,020,806	330,897,306	14,186,806	339,063,306	22,352,806	347,229,306	30,518,806	355,395,306	38,684,806	363,561,306	46,850,806
2017	307,987,000	281,901,483	(26,085,517)	290,067,483	(17,919,517)	298,233,483	(9,753,517)	306,399,483	(1,587,517)	314,565,483	6,578,483	322,731,483	14,744,483	330,897,483	22,910,483	339,063,483	31,076,483	347,229,483	39,242,483	355,395,483	47,408,483	363,561,483	55,574,483
2018	294,993,000	281,901,661	(13,091,339)	290,067,661	(4,925,339)	298,233,661	3,240,661	306,399,661	11,406,661	314,565,661	19,572,661	322,731,661	27,738,661	330,897,661	35,904,661	339,063,661	44,070,661	347,229,661	52,236,661	355,395,661	60,402,661	363,561,661	68,568,661
2019	278,677,500	281,901,838	3,224,338	290,067,838	11,390,338	298,233,838	19,556,338	306,399,838	27,722,338	314,565,838	35,888,338	322,731,838	44,054,338	330,897,838	52,220,338	339,063,838	60,386,338	347,229,838	68,552,338	355,395,838	76,718,338	363,561,838	84,884,338
2020	263,785,500	281,902,016	18,116,516	290,068,016	26,282,516	298,234,016	34,448,516	306,400,016	42,614,516	314,566,016	50,780,516	322,732,016	58,946,516	330,898,016	67,112,516	339,064,016	75,278,516	347,230,016	83,444,516	355,396,016	91,610,516	363,562,016	99,776,516
2021	250,280,500	281,902,193	31,621,693	290,068,193	39,787,693	298,234,193	47,953,693	306,400,193	56,119,693	314,566,193	64,285,693	322,732,193	72,451,693	330,898,193	80,617,693	339,064,193	88,783,693	347,230,193	96,949,693	355,396,193	105,115,693	363,562,193	113,281,693
2022	238,272,000	281,902,371	43,630,371	290,068,371	51,796,371	298,234,371	59,962,371	306,400,371	68,128,371	314,566,371	76,294,371	322,732,371	84,460,371	330,898,371	92,626,371	339,064,371	100,792,371	347,230,371	108,958,371	355,396,371	117,124,371	363,562,371	125,290,371
2023	221,591,500	281,902,548	60,311,048	290,068,548	68,477,048	298,234,548	76,643,048	306,400,548	84,809,048	314,566,548	92,975,048	322,732,548	101,141,048	330,898,548	109,307,048	339,064,548	117,473,048	347,230,548	125,639,048	355,396,548	133,805,048	363,562,548	141,971,048
2024	204,035,000	281,902,726	77,867,726	290,068,726	86,033,726	298,234,726	94,199,726	306,400,726	102,365,726	314,566,726	110,531,726	322,732,726	118,697,726	330,898,726	126,863,726	339,064,726	135,029,726	347,230,726	143,195,726	355,396,726	151,361,726	363,562,726	159,527,726
2025	185,602,500	281,902,903	96,300,403	290,068,903	104,466,403	298,234,903	112,632,403	306,400,903	120,798,403	314,566,903	128,964,403	322,732,903	137,130,403	330,898,903	145,296,403	339,064,903	153,462,403	347,230,903	161,628,403	355,396,903	169,794,403	363,562,903	177,960,403
2026	168,593,500	281,903,081	113,309,581	290,069,081	121,475,581	298,235,081	129,641,581	306,401,081	137,807,581	314,567,081	145,973,581	322,733,081	154,139,581	330,899,081	162,305,581	339,065,081	170,471,581	347,231,081	178,637,581	355,397,081	186,803,581	363,563,081	194,969,581
2027	153,154,000	281,903,258	128,749,258	290,069,258	136,915,258	298,235,258	145,081,258	306,401,258	153,247,258	314,567,258	161,413,258	322,733,258	169,579,258	330,899,258	177,745,258	339,065,258	185,911,258	347,231,258	194,077,258	355,397,258	202,243,258	363,563,258	210,409,258
2028	139,138,000	281,903,436	142,765,436	290,069,436	150,931,436	298,235,436	159,097,436	306,401,436	167,263,436	314,567,436	175,429,436	322,733,436	183,595,436	330,899,436	191,761,436	339,065,436	199,927,436	347,231,436	208,093,436	355,397,436	216,259,436	363,563,436	224,425,436
2029	126,399,500	281,903,613	155,504,113	290,069,613	163,670,113	298,235,613	171,836,113	306,401,613	180,002,113	314,567,613	188,168,113	322,733,613	196,334,113	330,899,613	204,500,113	339,065,613	212,666,113	347,231,613	220,832,113	355,397,613	228,998,113	363,563,613	237,164,113
2030	114,829,000	281,903,791	167,074,791	290,069,791	175,240,791	298,235,791	183,406,791	306,401,791	191,572,791	314,567,791	199,738,791	322,733,791	207,904,791	330,899,791	216,070,791	339,065,791	224,236,791	347,231,791	232,402,791	355,397,791	240,568,791	363,563,791	248,734,791
2031	104,025,000	281,903,968	177,878,968	290,069,968	186,044,968	298,235,968	194,210,968	306,401,968	202,376,968	314,567,968	210,542,968	322,733,968	218,708,968	330,899,968	226,874,968	339,065,968	235,040,968	347,231,968	243,206,968	355,397,968	251,372,968	363,563,968	259,538,968
2032	93,768,500	281,904,146	188,135,646	290,070,146	196,301,646	298,236,146	204,467,646	306,402,146	212,633,646	314,568,146	220,799,646	322,734,146	228,965,646	330,900,146	237,131,646	339,066,146	245,297,646	347,232,146	253,463,646	355,398,146	261,629,646	363,564,146	269,795,646
2033	84,424,500	281,904,323	197,479,823	290,070,323	205,645,823	298,236,323	213,811,823	306,402,323	221,977,823	314,568,323	230,143,823	322,734,323	238,309,823	330,900,323	246,475,823	339,066,323	254,641,823	347,232,323	262,807,823	355,398,323	270,973,823	363,564,323	279,139,823
2034	75,956,500	281,904,501	205,948,001	290,070,501	214,114,001	298,236,501	222,280,001	306,402,501	230,446,001	314,568,501	238,612,001	322,734,501	246,778,001	330,900,501	254,944,001	339,066,501	263,110,001	347,232,501	271,276,001	355,398,501	279,442,001	363,564,501	287,608,001
2035	68,255,000	281,904,678	213,649,678	290,070,678	221,815,678	298,236,678	229,981,678	306,402,678	238,147,678	314,568,678	246,313,678	322,734,678	254,479,678	330,900,678	262,645,678	339,066,678	270,811,678	347,232,678	278,977,678	355,398,678	287,143,678	363,564,678	295,309,678
2036	59,896,500	281,904,856	222,008,356	290,070,856	230,174,356	298,236,856	238,340,356	306,402,856	246,506,356	314,568,856	254,672,356	322,734,856	262,838,356	330,900,856	271,004,356	339,066,856	279,170,356	347,232,856	287,336,356	355,398,856	295,502,356	363,564,856	303,668,356
2037	53,545,500	281,905,034	228,359,534	290,071,034	236,525,534	298,237,034	244,691,534	306,403,034	252,857,534	314,569,034	261,023,534	322,735,034	269,189,534	330,901,034	277,355,534	339,067,034	285,521,534	347,233,034	293,687,534	355,399,034	301,853,534	363,565,034	310,019,534
2038	47,778,500	281,905,211	234,126,711	290,071,211	242,292,711	298,237,211	250,458,711	306,403,211	258,624,711	314,569,211	266,790,711	322,735,211	274,956,711	330,901,211	283,122,711	339,067,211	291,288,711	347,233,211	299,454,711	355,399,211	307,620,711	363,565,211	315,786,711
2039	42,559,000	281,905,389	239,346,389	290,071,389	247,512,389	298,237,389	255,678,389	306,403,389	263,844,389	314,569,389	272,010,389	322,735,389	280,176,389	330,901,389	288,342,389	339,067,389	296,508,389	347,233,389	304,674,389	355,399,389	312,840,389	363,565,389	321,006,389

Table 12: Fleet capacity with incremental vessel additions and annual vessel space surplus (deficit) considering mean production estimates.

5% Probability Production Estimates

Assumptions

Vessel load factor:	100%
Cargo density:	6.7686
Voyages/vessel/year:	25
Kvaerner Tanker capacity:	326,640 bbls

Production (bbls/year) Capacity w/ Kværner Vessels Added, Capacity Differential (bbl)

Year	95% Probability	0		1		2		3		4		5		6		7		8		9		10	
2001	388,944,000	491,556,330	102,612,330	499,722,330	110,778,330	507,888,330	118,944,330	516,054,330	127,110,330	524,220,330	135,276,330	532,386,330	143,442,330	540,552,330	151,608,330	548,718,330	159,774,330	556,884,330	167,940,330	565,050,330	176,106,330	573,216,330	184,272,330
2002	386,827,000	491,556,330	104,729,330	499,722,330	112,895,330	507,888,330	121,061,330	516,054,330	129,227,330	524,220,330	137,393,330	532,386,330	145,559,330	540,552,330	153,725,330	548,718,330	161,891,330	556,884,330	170,057,330	565,050,330	178,223,330	573,216,330	186,389,330
2003	387,374,500	491,556,330	104,181,830	499,722,330	112,347,830	507,888,330	120,513,830	516,054,330	128,679,830	524,220,330	136,845,830	532,386,330	145,011,830	540,552,330	153,177,830	548,718,330	161,343,830	556,884,330	169,509,830	565,050,330	177,675,830	573,216,330	185,841,830
2004	396,390,000	491,556,330	95,166,330	499,722,330	103,332,330	507,888,330	111,498,330	516,054,330	119,664,330	524,220,330	127,830,330	532,386,330	135,996,330	540,552,330	144,162,330	548,718,330	152,328,330	556,884,330	160,494,330	565,050,330	168,660,330	573,216,330	176,826,330
2005	395,477,500	491,556,330	96,078,830	499,722,330	104,244,830	507,888,330	112,410,830	516,054,330	120,576,830	524,220,330	128,742,830	532,386,330	136,908,830	540,552,330	145,074,830	548,718,330	153,240,830	556,884,330	161,406,830	565,050,330	169,572,830	573,216,330	177,738,830
2006	399,675,000	442,569,094	42,894,094	450,735,094	51,060,094	458,901,094	59,226,094	467,067,094	67,392,094	475,233,094	75,558,094	483,399,094	83,724,094	491,565,094	91,890,094	499,731,094	100,056,094	507,897,094	108,222,094	516,063,094	116,388,094	524,229,094	124,554,094
2007	399,054,500	348,471,336	(50,583,164)	356,637,336	(42,417,164)	364,803,336	(34,251,164)	372,969,336	(26,085,164)	381,135,336	(17,919,164)	389,301,336	(9,753,164)	397,467,336	(1,587,164)	405,633,336	6,578,836	413,799,336	14,744,836	421,965,336	22,910,836	430,131,336	31,076,836
2008	397,266,000	326,281,326	(70,984,674)	334,447,326	(62,818,674)	342,613,326	(54,652,674)	350,779,326	(46,486,674)	358,945,326	(38,320,674)	367,111,326	(30,154,674)	375,277,326	(21,988,674)	383,443,326	(13,822,674)	391,609,326	(5,656,674)	399,775,326	2,509,326	407,941,326	10,675,326
2009	393,616,000	304,091,316	(89,524,684)	312,257,316	(81,358,684)	320,423,316	(73,192,684)	328,589,316	(65,026,684)	336,755,316	(56,860,684)	344,921,316	(48,694,684)	353,087,316	(40,528,684)	361,253,316	(32,362,684)	369,419,316	(24,196,684)	377,585,316	(16,030,684)	385,751,316	(7,864,684)
2010	398,142,000	304,091,316	(94,050,684)	312,257,316	(85,884,684)	320,423,316	(77,718,684)	328,589,316	(69,552,684)	336,755,316	(61,386,684)	344,921,316	(53,220,684)	353,087,316	(45,054,684)	361,253,316	(36,888,684)	369,419,316	(28,722,684)	377,585,316	(20,556,684)	385,751,316	(12,390,684)
2011	349,451,000	281,901,306	(67,549,694)	290,067,306	(59,383,694)	298,233,306	(51,217,694)	306,399,306	(43,051,694)	314,565,306	(34,885,694)	322,731,306	(26,719,694)	330,897,306	(18,553,694)	339,063,306	(10,387,694)	347,229,306	(2,221,694)	355,395,306	5,944,306	363,561,306	14,110,306
2012	425,298,000	281,901,306	(143,396,694)	290,067,306	(135,230,694)	298,233,306	(127,064,694)	306,399,306	(118,898,694)	314,565,306	(110,732,694)	322,731,306	(102,566,694)	330,897,306	(94,400,694)	339,063,306	(86,234,694)	347,229,306	(78,068,694)	355,395,306	(69,902,694)	363,561,306	(61,736,694)
2013	437,671,500	281,901,306	(155,770,194)	290,067,306	(147,604,194)	298,233,306	(139,438,194)	306,399,306	(131,272,194)	314,565,306	(123,106,194)	322,731,306	(114,940,194)	330,897,306	(106,774,194)	339,063,306	(98,608,194)	347,229,306	(90,442,194)	355,395,306	(82,276,194)	363,561,306	(74,110,194)
2014	448,767,500	281,901,306	(166,866,194)	290,067,306	(158,700,194)	298,233,306	(150,534,194)	306,399,306	(142,368,194)	314,565,306	(134,202,194)	322,731,306	(126,036,194)	330,897,306	(117,870,194)	339,063,306	(109,704,194)	347,229,306	(101,538,194)	355,395,306	(93,372,194)	363,561,306	(85,206,194)
2015	467,820,500	281,901,306	(185,919,194)	290,067,306	(177,753,194)	298,233,306	(169,587,194)	306,399,306	(161,421,194)	314,565,306	(153,255,194)	322,731,306	(145,089,194)	330,897,306	(136,923,194)	339,063,306	(128,757,194)	347,229,306	(120,591,194)	355,395,306	(112,425,194)	363,561,306	(104,259,194)
2016	495,013,000	281,901,306	(213,111,694)	290,067,306	(204,945,694)	298,233,306	(196,779,694)	306,399,306	(188,613,694)	314,565,306	(180,447,694)	322,731,306	(172,281,694)	330,897,306	(164,115,694)	339,063,306	(155,949,694)	347,229,306	(147,783,694)	355,395,306	(139,617,694)	363,561,306	(131,451,694)
2017	521,220,000	281,901,483	(239,318,517)	290,067,483	(231,152,517)	298,233,483	(222,986,517)	306,399,483	(214,820,517)	314,565,483	(206,654,517)	322,731,483	(198,488,517)	330,897,483	(190,322,517)	339,063,483	(182,156,517)	347,229,483	(173,990,517)	355,395,483	(165,824,517)	363,561,483	(157,658,517)
2018	526,622,000	281,901,661	(244,720,339)	290,067,661	(236,554,339)	298,233,661	(228,388,339)	306,399,661	(220,222,339)	314,565,661	(212,056,339)	322,731,661	(203,890,339)	330,897,661	(195,724,339)	339,063,661	(187,558,339)	347,229,661	(179,392,339)	355,395,661	(171,226,339)	363,561,661	(163,060,339)
2019	500,488,000	281,901,838	(218,586,162)	290,067,838	(210,420,162)	298,233,838	(202,254,162)	306,399,838	(194,088,162)	314,565,838	(185,922,162)	322,731,838	(177,756,162)	330,897,838	(169,590,162)	339,063,838	(161,424,162)	347,229,838	(153,258,162)	355,395,838	(145,092,162)	363,561,838	(136,926,162)
2020	475,047,500	281,902,016	(193,145,484)	290,068,016	(184,979,484)	298,234,016	(176,813,484)	306,400,016	(168,647,484)	314,566,016	(160,481,484)	322,732,016	(152,315,484)	330,898,016	(144,149,484)	339,064,016	(135,983,484)	347,230,016	(127,817,484)	355,396,016	(119,651,484)	363,562,016	(111,485,484)
2021	451,906,500	281,902,193	(170,004,307)	290,068,193	(161,838,307)	298,234,193	(153,672,307)	306,400,193	(145,506,307)	314,566,193	(137,340,307)	322,732,193	(129,174,307)	330,898,193	(121,008,307)	339,064,193	(112,842,307)	347,230,193	(104,676,307)	355,396,193	(96,510,307)	363,562,193	(88,344,307)
2022	431,247,500	281,902,371	(149,345,129)	290,068,371	(141,179,129)	298,234,371	(133,013,129)	306,400,371	(124,847,129)	314,566,371	(116,681,129)	322,732,371	(108,515,129)	330,898,371	(100,349,129)	339,064,371	(92,183,129)	347,230,371	(84,017,129)	355,396,371	(75,851,129)	363,562,371	(67,685,129)
2023	412,158,000	281,902,548	(130,255,452)	290,068,548	(122,089,452)	298,234,548	(113,923,452)	306,400,548	(105,757,452)	314,566,548	(97,591,452)	322,732,548	(89,425,452)	330,898,548	(81,259,452)	339,064,548	(73,093,452)	347,230,548	(64,927,452)	355,396,548	(56,761,452)	363,562,548	(48,595,452)
2024	394,857,000	281,902,726	(112,954,274)	290,068,726	(104,788,274)	298,234,726	(96,622,274)	306,400,726	(88,456,274)	314,566,726	(80,290,274)	322,732,726	(72,124,274)	330,898,726	(63,958,274)	339,064,726	(55,792,274)	347,230,726	(47,626,274)	355,396,726	(39,460,274)	363,562,726	(31,294,274)
2025	369,964,000	281,902,903	(88,061,097)	290,068,903	(79,895,097)	298,234,903	(71,729,097)	306,400,903	(63,563,097)	314,566,903	(55,397,097)	322,732,903	(47,231,097)	330,898,903	(39,065,097)	339,064,903	(30,899,097)	347,230,903	(22,733,097)	355,396,903	(14,567,097)	363,562,903	(6,401,097)
2026	337,150,500	281,903,081	(55,247,419)	290,069,081	(47,081,419)	298,235,081	(38,915,419)	306,401,081	(30,749,419)	314,567,081	(22,583,419)	322,733,081	(14,417,419)	330,899,081	(6,251,419)	339,065,081	1,914,581	347,231,081	10,080,581	355,397,081	18,246,581	363,563,081	26,412,581
2027	305,687,500	281,903,258	(23,784,242)	290,069,258	(15,618,242)	298,235,258	(7,452,242)	306,401,258	713,758	314,567,258	8,879,758	322,733,258	17,045,758	330,899,258	25,211,758	339,065,258	33,377,758	347,231,258	41,543,758	355,397,258	49,709,758	363,563,258	57,875,758
2028	277,144,500	281,903,436	4,758,936	290,069,436	12,924,936	298,235,436	21,090,936	306,401,436	29,256,936	314,567,436	37,422,936	322,733,436	45,588,936	330,899,436	53,754,936	339,065,436	61,920,936	347,231,436	70,086,936	355,397,436	78,252,936	363,563,436	86,418,936
2029	251,266,000	281,903,613	30,637,613	290,069,613	38,803,613	298,235,613	46,969,613	306,401,613	55,135,613	314,567,613	63,301,613	322,733,613	71,467,613	330,899,613	79,633,613	339,065,613	87,799,613	347,231,613	95,965,613	355,397,613	104,131,613	363,563,613	112,297,613
2030	227,833,000	281,903,791	54,070,791	290,069,791	62,236,791	298,235,791	70,402,791	306,401,791	78,568,791	314,567,791	86,734,791	322,733,791	94,900,791	330,899,791	103,066,791	339,065,791	111,232,791	347,231,791	119,398,791	355,397,791	127,564,791	363,563,791	135,730,791
2031	206,261,500	281,903,968	75,642,468	290,069,968	83,808,468	298,235,968	91,974,468	306,401,968	100,140,468	314,567,968	108,306,468	322,733,968	116,472,468	330,899,968	124,638,468	339,065,968	132,804,468	347,231,968	140,970,468	355,397,968	149,136,468	363,563,968	157,302,468
2032	186,259,500	281,904,146	95,644,646	290,070,146	103,810,646	298,236,146	111,976,646	306,402,146	120,142,646	314,568,146	128,308,646	322,734,146	136,474,646	330,900,146	144,640,646	339,066,146	152,806,646	347,232,146	160,972,646	355,398,146	169,138,646	363,564,146	177,304,646
2033	168,155,500	281,904,323	113,748,823	290,070,323	121,914,823	298,236,323	130,080,823	306,402,323	138,246,823	314,568,323	146,412,823	322,734,323	154,578,823	330,900,323	162,744,823	339,066,323	170,910,823	347,232,323	179,076,823	355,398,323	187,242,823	363,564,323	195,408,823
2034	151,694,000	281,904,501	130,210,501	290,070,501	138,376,501	298,236,501	146,542,501	306,402,501	154,708,501	314,568,501	162,874,501	322,734,501	171,040,501	330,900,501	179,206,501	339,066,501	187,372,501	347,232,501	195,538,501	355,398,501	203,704,501	363,564,501	211,870,501
2035	137,897,000	281,904,678	144,007,678	290,070,678	152,173,678	298,236,678	160,339,678	306,402,678	168,505,678	314,568,678	176,671,678	322,734,678	184,837,678	330,900,678	193,003,678	339,066,678	201,169,678	347,232,678	209,335,678	355,398,678	217,501,678	363,564,678	225,667,678
2036	124,027,000	281,904,856	157,877,856	290,070,856	166,043,856	298,236,856	174,209,856	306,402,856	182,375,856	314,568,856	190,541,856	322,734,856	198,707,856	330,900,856	206,873,856	339,066,856	215,039,856	347,232,856	223,205,856	355,398,856	231,371,856	363,564,856	239,537,856
2037	112,675,500	281,905,034	169,229,534	290,071,034	177,395,534	298,237,034	185,561,534	306,403,034	193,727,534	314,569,034	201,893,534	322,735,034	210,059,534	330,901,034	218,225,534	339,067,034	226,391,534	347,233,034	234,557,534	355,399,034	242,723,534	363,565,034	250,889,534
2038	101,214,500	281,905,211	180,690,711	290,071,211	188,856,711	298,237,211	197,022,711	306,403,211	205,188,711	314,569,211	213,354,711	322,735,211	221,520,711	330,901,211	229,686,711	339,067,211	237,852,711	347,233,211	246,018,711	355,399,211	254,184,711	363,565,211	262,350,711
2039	90,812,000	281,905,389	191,093,389	290,071,389	199,259,389	298,237,389	207,425,389	306,403,389	215,591,389	314,569,389	223,757,389	322,735,389	231,923,389	330,901,389	240,089,389	339,067,389	248,255,389	347,233,389	256,421,389	355,399,389	264,587,389	363,565,389	272,753,389

Table 13: Fleet capacity with incremental vessel additions and annual vessel space surplus (deficit) considering 5% probability production estimates.