United States General Accounting Office

GAO

Report to Congressional Committees

July 1999

# ALASKAN NORTH SLOPE OIL

# Limited Effects of Lifting Export Ban on Oil and Shipping Industries and Consumers



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**United States General Accounting Office**
**Washington, D.C. 20548**

**Resources, Community, and**
**Economic Development Division**

B-282694

July 1, 1999

Congressional Committees

This report responds to the mandate in Public Law 104-58, title II, that GAO review Alaska and California energy production and the effects of lifting the ban on exporting Alaskan North Slope oil. As agreed with your offices, this report addresses the effects of lifting the export ban on (1) Alaskan North Slope and California crude oil prices and production and (2) refiners, consumers, and the oil shipping industry (including the tanker fleet, the tanker building industry, and the tanker repair industry) on the U.S. West Coast. To put the effects of lifting the ban in context, the report covers changes in Alaska and California production during the past decade (1989 through 1998). This report also discusses export-related environmental issues related to lifting the export ban.

We are sending copies of this report to the Honorable William M. Daley, Secretary of Commerce; the Honorable Bill Richardson, Secretary of Energy; the Honorable Bruce Babbitt, Secretary of Interior; and the Honorable Rodney E. Slater, Secretary of Transportation. Copies will also be made available to others upon request.

If you have any questions about this report, please contact me at (202) 512-3841. Major contributors to this report are listed in appendix III.

Susan D. Kladiva
Associate Director, Energy,
Resources, and Science Issues

B-282694

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# Executive Summary

## Purpose

Over 12 billion barrels of crude oil have been produced on the Alaskan North Slope since oil was discovered there in 1968. Initially, U.S. tankers transported Alaskan North Slope oil to California and other U.S. refineries, partly because the Congress banned exporting such oil to foreign countries. The ban, intended in part to reduce U.S. dependence on foreign oil, was controversial from the beginning. Advocates of lifting the ban argued that selling the oil in the world market would increase the demand for it. Increased demand, in turn, was expected to increase the price and production of Alaska and California crude oil, thereby increasing the states' revenues. Opponents argued that increased crude oil prices resulting from lifting the ban would reduce some refiners' profit margins and force some to become dependent on Alaskan North Slope oil because they would have no practical access to cheaper foreign oil. Opponents also argued that lifting the ban would take business from the U.S. shipping industry because operators of oil tankers would use low-cost foreign tankers and crews to export Alaskan North Slope oil and have tankers repaired in low-cost foreign shipyards.

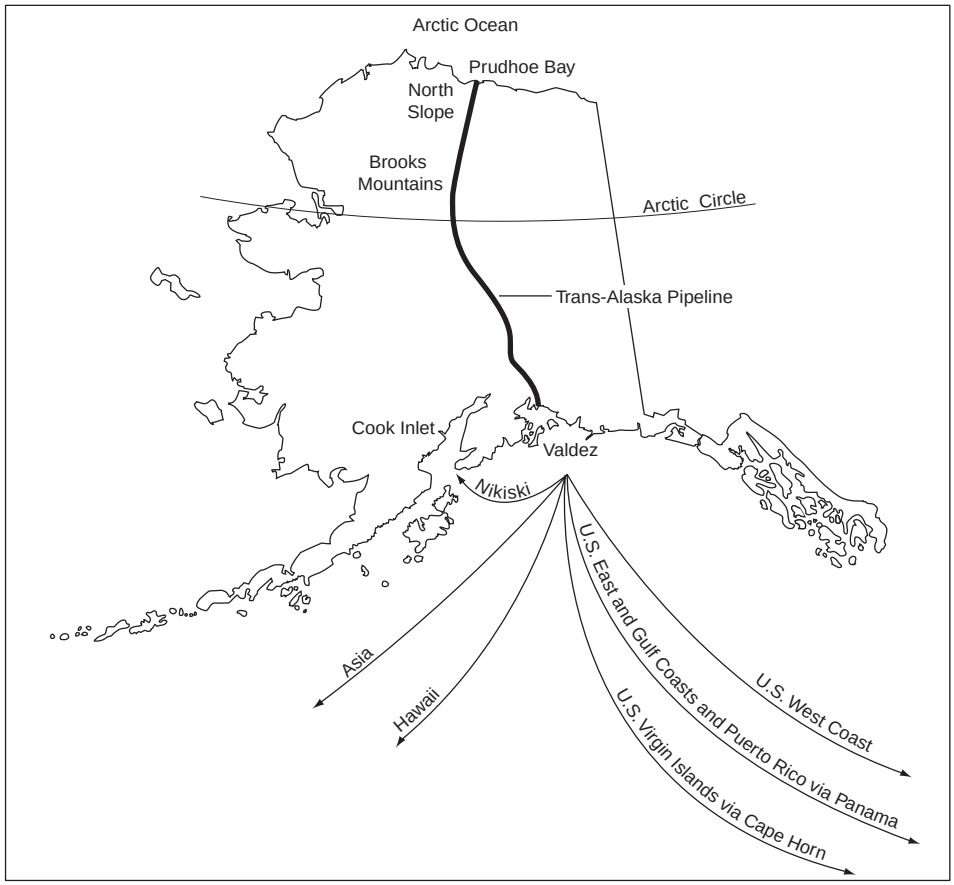
Legislation enacted in 1995 allowed Alaskan North Slope oil to be exported (P.L. 104-58, title II). That legislation also required GAO to review Alaska and California energy production and the effects of lifting the export ban. As agreed with the Senate Committee on Energy and Natural Resources and the House Committees on Resources and on Commerce, this report addresses the effects of lifting the export ban on (1) Alaskan North Slope and California crude oil prices and production and (2) refiners, consumers, and the Alaskan North Slope oil-shipping industry (including the tanker fleet, the tanker building industry, and the tanker repair industry) on the U.S. West Coast. For the purpose of this report, the U.S. West Coast includes Alaska, California, Hawaii, Oregon, and Washington State. To put the effects of lifting the ban in context, this report discusses changes in Alaska and California production during the past decade (1989 through 1998). This report also discusses export-related environmental issues resulting from lifting the ban (see app. I).

## Background

In 1968, billions of barrels of crude oil were discovered in Prudhoe Bay on the Alaskan North Slope, significantly affecting U.S. oil and oil-shipping industries. Alaska became a major U.S. oil-producing state. U.S. West Coast refiners retooled to efficiently process Alaskan North Slope oil, which accounted for about 43 percent of all crude oil that was refined on the West Coast in 1998. New tankers were also built to transport the oil

from Valdez, Alaska, on Prince William Sound, to West Coast and other refineries. The first commercial tanker carrying Alaskan North Slope oil left Valdez, Alaska, for the West Coast on August 1, 1977. The first commercial tanker exporting such oil left Valdez for Asia on May 31, 1996, approximately 6 months after the legislation lifting the ban was enacted.[1] (See fig. 1.)

**Figure 1: Locations of Alaska Oil Fields and Tanker Routes From Valdez, Alaska, to Refineries That Received Alaskan North Slope Oil, 1977-98**




Source: Alyeska Pipeline Service Company, BP-Amoco, Alaska Department of Natural Resources, and Energy Security: Impacts of Lifting Alaskan North Slope Oil Exports Ban (GAO/RCED-91-21, Nov. 8, 1990).

[1]The Nov. 28, 1995, legislation authorized the export of Alaskan North Slope oil unless the President found, within 5 months of the date of enactment, that exporting the oil was not in the national interest.

GAO conducted statistical and economic analyses of crude oil price and production data, reviewed related studies, and obtained the views of federal, state, oil industry, shipping industry, and other officials to determine the effects of lifting the export ban. To determine the effects of lifting the ban on oil prices, GAO developed a time-series model. Because oil prices are influenced by many factors in addition to removing the ban, GAO controlled for these other factors by modeling the difference between the prices of West Coast oils and the prices of similar oils in other markets. Furthermore, where applicable, established economic concepts and theories were applied to predict the likely effects on Alaskan North Slope and California crude oil production in the future. When important price, production, refining, and shipping data were unavailable because they were proprietary, GAO attempted, to the extent possible, to obtain such information from alternative sources. However, because of proprietary data limitations, GAO was unable to determine the full effects of lifting the export ban on cost increases for refiners using Alaskan North Slope or comparable California oil or on the U.S. West Coast market in general.

## Results in Brief

Lifting the export ban raised the relative prices of Alaskan North Slope and comparable California oils between $.98 and $1.30 higher per barrel than they would have been had the ban not been lifted.[2] To date, these price increases have not had an observable effect on Alaskan North Slope and California crude oil production. Nevertheless, future oil production should be higher than it would have been because higher crude oil prices have given producers an incentive to produce more oil. According to projections by the Alaska Department of Revenue and to oil industry officials, new oil fields developed in Alaska since the ban was lifted are expected to increase Alaskan North Slope oil production by an average of 115,000 barrels per day for the next two decades. However, it was not possible for GAO to separate the effects of lifting the ban on expected production from the effects of broader oil market changes occurring at the same time. For example, relatively high world oil prices in 1996 and 1997 encouraged oil producers to expand exploration and development activities, while low prices in 1998 caused producers to close wells and reduce development activities. Moreover, this expected production increase will not reverse the decade-long decline of Alaska and California

[2] The price of Alaskan North Slope and comparable California oils rose in comparison to selected, widely traded world oils commonly used as benchmarks for comparing oils and setting prices.

oil production, which is expected to continue as aging oil fields become depleted.

Lifting the export ban increased some refiners' costs but had limited effects on consumers and the oil-shipping industry on the West Coast. While higher prices for Alaskan North Slope and comparable California oil increased the costs of some individual refiners using that oil, it was not possible to determine the extent of cost increases for those refiners or the West Coast market in general. Despite higher crude oil prices for some refiners, no observed increases occurred in the prices of three important petroleum products used by consumers on the West Coast--gasoline, diesel, and jet fuel. Lifting the ban has also had a minimal effect to date on most oil tanker operators that transport Alaskan North Slope oil, the U.S. shipbuilding industry, and the West Coast ship repair industry. However, shipbuilding and ship repair industry officials on the West Coast are concerned that Alaskan North Slope oil tanker business may shift in the future to low-cost foreign shipyards.

# Principal Findings

## Lifting the Export Ban Increased Oil Prices and Should Increase Future Oil Production

Lifting the ban caused the relative prices of Alaskan North Slope and California oils with comparable characteristics to be between $.98 and $1.30 higher per barrel than they would have been had the ban not been removed, according to GAO's analyses.[3] In addition, lifting the ban led to exports to Asia, which allowed oil companies to reduce their shipping costs for the oil that was exported because Asian ports are closer than the ports for the U.S. Gulf Coast and U.S. Virgin Islands, where some Alaskan North Slope oil was shipped before the ban was lifted. However, lifting the ban has not led to a large volume of exports--only about 5 percent (60,000 barrels per day) of all Alaskan North Slope production has been exported to foreign countries since the ban was lifted. Furthermore, oil production in Alaska and California has had no observable increase to date as a result of lifting the export ban.

[3] In conducting these analyses, GAO selected three world oils that are commonly used as benchmarks for comparing oil prices or with characteristics (weight and sulfur content) comparable to Alaskan North Slope oil. The lighter the weight and lower the sulfur content, the higher the quality of crude oil because it costs less to refine this oil.

GAO believes future production should increase because the ban was lifted, although not enough to reverse the decade-long decline in oil production as aging oil fields become depleted. Higher market prices and lower shipping costs have given oil producers more incentive to develop new oil fields. Industry and government officials told us that the development of new Alaskan North Slope oil fields increased during the period after the export ban was removed. These new fields are expected to average about 115,000 barrels per day between 1999 and 2020. Some oil officials attributed part of this increase to the effects of lifting the ban, while others said that these effects could not be separated from broader market conditions. These officials cited high world oil prices in 1996 and 1997 as one of the factors that encouraged them to open new fields in Alaska. Conversely, oil officials said that low oil prices in 1998 caused them to close California wells to avoid costly maintenance and to modify their plans for the future development of the Alaskan North Slope. GAO could not separate the effects of lifting the ban on expected production from these broader market changes. Nonetheless, while production is expected to increase, the increase will not reverse the overall long-term decline in Alaska and California oil production as aging oil fields become depleted. Production in both states decreased almost every year from 1989 through 1998 and is expected to fall further in the future.

## The Effects of Lifting the Oil Export Ban on Refiners, Consumers, and the Shipping Industry on the West Coast Have Been Generally Limited

Lifting the export ban generally had limited effects on refiners, consumers, and the shipping industry on the West Coast. Higher market prices for Alaskan North Slope and comparable California oils translate directly into higher costs for refiners buying these oils. However, not all refiners were affected equally, as illustrated in the following hypothetical cases. For refiners that used large volumes of Alaskan North Slope and comparable California oils, costs would have risen when the prices of these oils rose. If the refiners bought only these oils at the market price, costs would have risen by exactly the amount the price increased as a result of lifting the ban--about $.98 to $1.30 per barrel. For refiners that did not use significant quantities of these oils, cost would have been less affected by price increases. Finally, for refiners that used mostly oil that came from their own companies' wells, information was not available to determine how price increases affected these companies' costs. Because data on all refiners' crude oil purchases and internal transactions are proprietary, GAO

could not determine the increase in refiners' costs that was due to higher Alaskan North Slope and California oil prices.

Despite higher crude oil costs for some refiners, no observed increases occurred in West Coast consumer prices as a result of lifting the export ban. GAO analyzed three important petroleum products used by consumers, which accounted for about 80 percent of the products produced by West Coast refiners, and found no significant increases in prices. According to GAO's statistical and economic analyses, the prices of gasoline, diesel, and jet fuel on the West Coast did not significantly change as a result of lifting the export ban. Moreover, consumer groups and industry experts GAO contacted were unaware of any adverse effects on consumers from lifting the ban.

To date, lifting the export ban has had limited effects on most oil tanker operators that transport Alaskan North Slope oil, the shipbuilding industry, and the ship repair industry. The effect on tanker operators has been limited because most Alaskan North Slope oil--about 95 percent--has continued to be shipped to the U.S. West Coast. Officials of charter shipping companies carrying the exported oil said that lifting the ban had benefited their business by slightly increasing the demand for tankers. In 1996 and 1997, according to GAO's analysis, exports increased the demand for U.S. tankers by one or two and created an estimated 58 to 115 new U.S. crew jobs on tankers used to transport Alaskan North Slope oil. This was because U.S.-registered tankers with U.S. crews used to export Alaskan North Slope oil to Asia replaced foreign-registered tankers with foreign crews carrying such oil to the U.S. Virgin Islands.[4] These new jobs partially offset overall job losses in the fleet resulting from declines in Alaskan North Slope production during the past decade.

The U.S. shipbuilding and ship repair industries also have experienced few effects. According to oil industry officials, foreign-built tankers have not been used to export Alaskan North Slope oil, and U.S. shipbuilders have not lost orders for new tankers to foreign shipyards. Although U.S. shipbuilders expected at least 10 new tanker orders in the 1990s, only 3

[4] The 1995 export legislation mandated that U.S.-documented (including U.S.-registered and -crewed) and U.S.-owned but not necessarily U.S.-built tankers be used to export Alaskan North Slope oil. Foreign-built tankers with foreign crews are permitted to carry such oil to the U.S. Virgin Islands under an exception in the Jones Act, which, along with several related trade laws, requires that any vessel transporting cargo between U.S. ports must be U.S.-built, U.S.-flagged (registered), U.S.-owned, and U.S.–crewed.

have materialized to date. Thus, half of the Alaskan North Slope oil tanker fleet consists of older, single-hulled tankers built in the 1970s or before.[5] Furthermore, while exporting crude oil has given tanker fleet operators an added incentive to repair Alaskan North Slope oil tankers in low-cost Asian shipyards during export trips, there has not been a trend toward more foreign repairs since exports began, according to U.S. Customs' repair data. However, officials in the U.S. shipbuilding and West Coast ship repair industries said that they are concerned that business may shift in the future to foreign shipyards. For example, West Coast tanker repair industry officials told us that a trend toward more foreign repairs could be beginning. They cited as an example a U.S. charter shipping company that used a U.S. tanker to carry an export shipment of Alaskan North Slope oil to Korea and then had the tanker repaired in a Korean shipyard at a cost well below estimated prices for repair in a U.S. West Coast shipyard.

## Recommendations

This report makes no recommendations.

## Agency Comments

GAO provided a draft of this report to the Department of Energy, including its Energy Information Administration and Office of Policy, for review and comment. GAO discussed the report with Energy Information Administration officials, including the Director, Petroleum Division, and Office of Policy staff. While the Department did not take a position on the findings presented in the report, it provided clarifying comments that GAO incorporated, where appropriate.

[5] The Oil Pollution Act of 1990 requires that all single-hulled tankers be phased out of operation by 2015, depending on the tanker age, and that all new tankers built be double-hulled to reduce the effects of oil spills in the event of an accident.

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## Figures



**Abbreviations**

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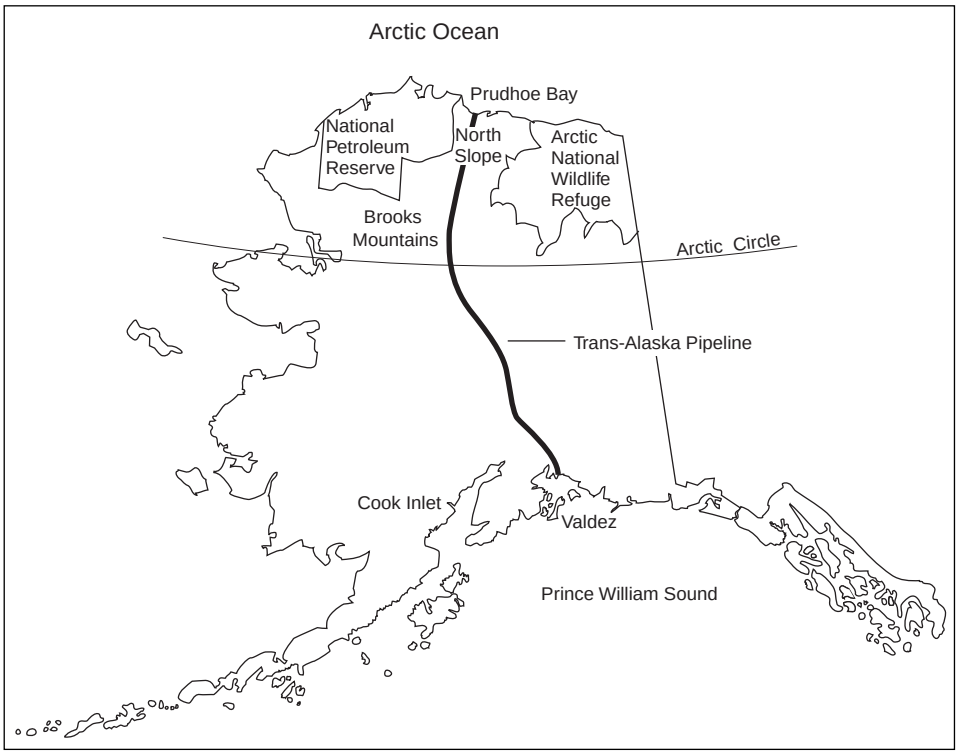
|---|---|
| ARCO | Atlantic Richfield Company |
| BP-Amoco | British Petroleum-Amoco |

# Introduction

In January 1968, oil was discovered in Prudhoe Bay on Alaska's North Slope—an 88,000 square-mile frozen landmass extending from the foothills of the Brooks Mountain Range to the Arctic Ocean, as shown in figure 1.1. The Prudhoe Bay area, located about 250 miles north of the Arctic Circle and about 1,200 miles south of the North Pole, had no local road system and was inaccessible by tanker most of the year because extremely cold temperatures freeze the nearby Arctic Ocean. Consequently, oil companies began planning the construction of the Trans-Alaska Pipeline System—an 800-mile pipeline to transport oil from the frozen Alaskan North Slope to Valdez, on Alaska's Prince William Sound, for shipment to distant refineries. The Congress approved pipeline construction in November 1973, and construction was completed in July 1977. The first commercial tanker carrying Alaskan North Slope oil from Valdez left for the U.S. West Coast on August 1, 1977.

**Figure 1.1: Map of Showing Locations of Alaska Oil Fields**




Source: Alyeska Pipeline Service Company, BP-Amoco, and Alaska Department of Natural Resources.

## Alaskan North Slope Oil Discovery Was Largest in U.S. History

Alaska contains huge quantities of crude oil. The Prudhoe Bay discovery was the largest in North America. Oil companies estimate that the state had at least 41 billion barrels of oil in place at the time of the North Slope discovery. According to Alaska Department of Natural Resources data, updated May 1998, an estimated 19.5 billion barrels were extractable using today's technology and under prevailing economic conditions (commonly referred to as proven reserves).

Of the 19.5 billion barrels of proven reserves, about 13.8 billion barrels have already been produced by 22 fields. Thirteen Alaskan North Slope fields that contained an estimated 18.2 billion barrels of proven reserves have produced about 12.5 billion barrels. Prudhoe Bay, the oldest and largest field on the Alaskan North Slope, accounted for about 73 percent of those reserves and about 80 percent of total production. The remaining proven reserves are contained in nine Cook Inlet fields that have already produced about 1.2 billion barrels. Since 1978, the first full year of Alaskan North Slope oil production after the completion of the Trans-Alaska Pipeline, Alaska has accounted for between 14 and 25 percent of U.S. crude oil production and has ranked among the largest U.S. crude oil-producing states every year.

The Alaska Department of Natural Resources' estimates, however, did not include all Alaska oil. The estimates excluded Alaskan North Slope oil fields in various stages of development that had not produced measurable quantities of oil by 1998. They also excluded the Alaska National Petroleum Reserve, the Arctic National Wildlife Refuge, and undeveloped Outer Continental Shelf areas. Oil analysts believe these areas contain billions of barrels of proven reserves.[1]

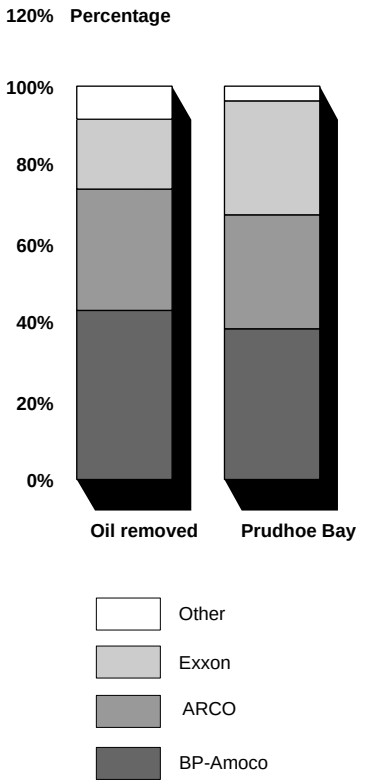
British Petroleum-Amoco Corporation (BP-Amoco), Atlantic Richfield Company (ARCO), and Exxon have controlling interests in most Alaskan North Slope oil production. As shown in figure 1.2, in 1998 these three companies owned production rights for over 90 percent of the Prudhoe Bay field and accounted for over 90 percent of all the oil removed from the Alaskan North Slope.[2] Fourteen other companies also had production

[1] Alaska also has trillions of cubic feet of natural gas that Alaskan North Slope oil producers would like to commercialize. The oil industry is exploring ways to convert the natural gas to liquid to be transported off the North Slope, possibly through traditional pipelines such as the Trans-Alaska Pipeline.

[2] BP and Amoco merged in 1998. In April 1999, BP-Amoco and ARCO confirmed plans to merge.

interests in the Alaskan North Slope in 1998, including companies owned by native Alaskan groups.

**Figure 1.2: Percent of Oil Removed From Alaskan North Slope and Percent of Production Rights in Prudhoe Bay Oil Field, by Major Oil Company, in 1998**




Source: Alaska Department of Natural Resources and Energy Security: Impacts of Lifting Alaskan North Slope Oil Exports Ban (GAO/RCED-91-21, Nov. 8, 1990)

## Alaskan North Slope Oil Discovery Changed the West Coast Oil Industry

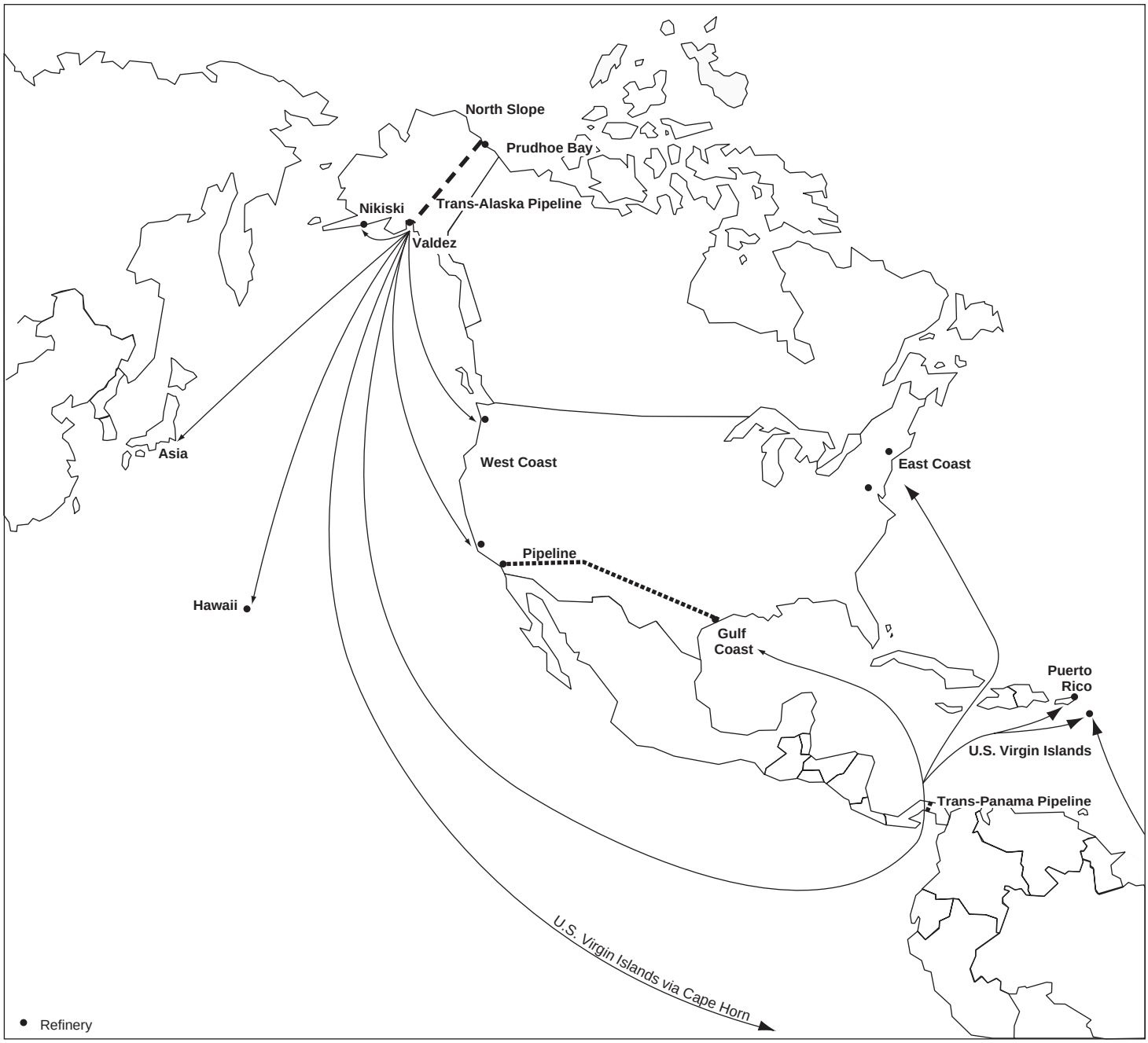
The addition of Alaskan North Slope oil production to the oil produced in California and other West Coast states meant that, for the first time, production on the U.S. West Coast was greater than West Coast refiners' demand for crude oil.[3] Consequently, oil producers in Alaska looked to other markets. Figure 1.3 shows the historical shipping routes for Alaskan North Slope oil and the location of potential refining markets. This figure illustrates the principal difference between these potential markets—namely, the distance between these markets and the Port of Valdez.

Generally, shorter shipping distances translate into lower transportation costs and higher profits for oil producers, although other factors, such as tanker size, also affect costs.[4] The West Coast is the closest domestic market for Alaskan North Slope oil, and Asia is closer than most other U.S. markets, such as the U.S. Gulf Coast and U.S. Virgin Islands. However, the Congress had banned the export of Alaskan North Slope oil. Therefore, Alaskan North Slope oil producers took oil not sold on the West Coast to more distant domestic markets.

[3] For the purpose of this report, the West Coast includes Alaska, California, Hawaii, Oregon, and Washington State.

[4] Because crew size and operating costs other than fuel are basically constant regardless of tanker size, the per-barrel cost to transport oil can be less for larger tankers than for smaller tankers.

**Figure 1.3: Shipping Routes for Alaskan North Slope Oil Tankers, 1989-98**




Source: Energy Security: Impacts of Lifting Alaskan North Slope Oil Exports Ban (GAO/RCED-91-21, Nov. 8, 1990).

## West Coast Refineries Retooled to Process Alaskan North Slope Oil

The proximity to Valdez, along with the ban on exports, made the West Coast the preferred destination for the sellers of Alaskan North Slope oil. Because this oil's characteristics (weight and sulfur content) differed from those of foreign oil, refiners had to invest in additional refining equipment to handle the Alaskan North Slope oil. After West Coast refiners retooled to efficiently process that oil, Alaskan North Slope oil took the place of much of the foreign oil that West Coast refiners had imported. In 1998, Alaskan North Slope oil constituted about 43 percent of all crude oil refined on the West Coast.

## New Tankers Were Built to Transport Alaskan North Slope Oil

The discovery of oil on the Alaskan North Slope, along with the export ban, also had an effect on the U.S. oil-shipping industry. U.S. shipyards built over 50 tankers in the 1970s and 1980s to carry crude oil from Valdez to distant refineries. Until the Congress lifted the ban on exporting Alaskan North Slope oil, tankers transported the Alaskan North Slope oil to U.S. ports. As a result, the tankers were required to comply with the Jones Act. The Jones Act, along with several related trade laws, require that any vessel transporting cargo between U.S. ports must be U.S.-built, U.S.-flagged (registered), U.S.-owned, and U.S.-crewed. Under an exception in the Jones Act, foreign-built tankers were allowed to transport oil from Valdez to the U.S. Virgin Islands.

# Original Ban Was Debated and Ultimately Removed

The Congress banned exporting Alaskan North Slope oil when it authorized the construction of the Trans-Alaska Pipeline in 1973. The legislation, which was enacted in the midst of the Arab oil embargo, amended the Mineral Leasing Act of 1920 and restricted the export of U.S. oil transported over a federal right-of-way. Exports were allowed only if the President found that they would not diminish the quantity or quality of oil available to the United States and were in the national interest. The Energy Policy and Conservation Act of 1975, the Export Administration Act of 1979, and various other laws provided additional restrictions on Alaskan North Slope oil exports. These restrictions were intended, in part, to reduce U.S. dependency on foreign oil, ensure that Alaskan North Slope oil would be used to benefit U.S. citizens, and protect the U.S. economy from a drain of scarce resources.

The export ban was controversial from its beginning, and the pros and cons of lifting it were debated in congressional hearings and in other discussions for years. In addition, several studies addressed the likely effects of lifting

the ban. At issue was who would benefit and who would not benefit from lifting the ban.

Advocates of lifting the export ban argued that it created a surplus of Alaskan North Slope oil on the West Coast, in turn depressing price and production and limiting state governments' revenues.[5] For example, the Department of Energy concluded in 1994 that lifting the ban on exporting Alaskan North Slope oil would (1) increase the price of the oil by expanding its markets, (2) increase Alaska and California revenues through increased royalties and taxes, and (3) generate new economic activity and employment in Alaska and California.[6] Moreover, these benefits were expected to accrue without an increase in gasoline prices.

Opponents argued that lifting the ban would have adverse consequences. For example, in a 1995 report prepared for the Coalition to Keep Alaska Oil, consultants agreed with the Department of Energy's 1994 conclusions that the price and production of Alaskan North Slope oil would increase. But they also predicted that oil companies' export-related revenue and production gains would be small and of short duration because the West Coast would become dependent on foreign imports.[7] The consultants also predicted that refiners that only refine crude oil and do not produce oil (commonly referred to as independent refiners) would become dependent on Alaskan North Slope oil because they would have no practical access to cheaper foreign oil and their profit margins would decrease. Furthermore, the report stated, consumers' prices would increase because crude oil prices would be higher. Finally, allowing companies to export oil on foreign-built tankers instead of more costly U.S.-built tankers was expected to hurt the U.S. shipping industry.

In 1990, we reported that lifting the ban would likely increase the price of Alaskan North Slope oil.[8] We reported that some oil would likely be exported to Asia instead of being shipped to the U.S. East and Gulf Coasts,

[5] States receive severance tax for oil extracted from the ground for consumption in other states, royalty revenue based on the value of oil, income tax, and property tax.

[6] Exporting Alaskan North Slope Crude Oil: Benefits and Costs, Department of Energy (June 1994).

[7] National Consequences of Exporting Alaska North Slope Oil, Wilson Gillette & Co., Petroleum Economics and Logistics Consultants (May 1995), prepared for the Coalition to Keep Alaska Oil—a Washington, D.C.-based group that opposed exporting Alaska oil.

[8] Alaskan Crude Oil Exports (GAO/T-RCED-90-59, Apr. 5, 1990) and Energy Security: Impacts of Lifting Alaskan North Slope Oil Exports Ban (GAO/RCED-91-21, Nov. 8, 1990).

the U.S. Virgin Islands, Puerto Rico, and possibly some U.S. West Coast ports because transportation costs to Asia were lower. We also reported that lifting the ban would promote economic efficiency by increasing domestic oil production and allowing better use of refinery resources. Finally, we stated that lifting the ban would increase the decline in demand for U.S. tankers because Alaskan North Slope oil would be exported on foreign-flagged instead of U.S.-flagged tankers.

In 1995, the Congress lifted the ban on exporting Alaskan North Slope oil (P.L. 104-58, title II). The 1995 act eliminated the export restrictions in the Mineral Leasing Act of 1920 and various other statutes and regulations. The act also requires that oil tankers transporting Alaskan North Slope oil to foreign destinations be U.S. documented (including U.S.-registered and U.S.-crewed) but not necessarily U.S.-built. According to the conference report accompanying the 1995 legislation, the purpose of lifting the export ban was to allow Alaskan North Slope crude oil to compete with other crude oil in the world market under normal market conditions. The first commercial tanker exporting Alaskan North Slope oil left Valdez for Asia on May 31, 1996, about 6 months after the ban was lifted.[9]

## Objectives, Scope, and Methodology

The 1995 law required us to review Alaska and California energy production and the effects of lifting the ban on independent oil refiners, consumers, and shipbuilding and ship repair yards on the West Coast and Hawaii. As agreed with the Senate Committee on Energy and Natural Resources and the House Committees on Resources and on Commerce, this report responds to that mandate and addresses the effects of lifting the export ban on (1) Alaskan North Slope and California crude oil prices and production and (2) refiners, consumers, and the oil-shipping industry (including the tanker fleet, the tanker building industry, and the tanker repair industry) on the U.S. West Coast. To put the effects of lifting the ban in context, this report discusses changes in Alaska and California production during the past decade (1989 through 1998). This report also discusses export-related environmental issues resulting from lifting the ban (see app. I).

To assess the effect of lifting the export ban on Alaskan North Slope and California crude oil prices and production, we collected and analyzed

[9] The Nov. 28, 1995, legislation authorized the export of Alaskan North Slope oil unless the President found, within 5 months of the date of enactment, that exporting the oil was not in the national interest.

crude oil price and production data from the Department of Energy, the Alaska Departments of Natural Resources and of Revenue, the California Departments of Conservation and of Revenue, selected oil producers and refiners, the Alyeska Pipeline Service Company—the organization that operates the Trans-Alaska Pipeline System—and Platts Oil Prices Data Base as reported by Standard & Poor's *DRI*. We also reviewed previous GAO reports, studies, and other available literature. In addition, we interviewed federal, state, and oil industry officials to obtain their views on the effects of lifting the ban. Furthermore, we conducted statistical analyses using oil-price data before and after the ban was lifted to determine how lifting the export ban had affected the prices of Alaskan North Slope and California oil. A complete discussion of our statistical and economic analyses for determining the effects of lifting the export ban on Alaskan North Slope and California crude oil prices is in appendix II.

To assess the effects of lifting the export ban on refiners, consumers, and the oil-shipping industry on the West Coast, we interviewed West Coast crude oil-refining officials, consumer groups, and oil-shipping industry officials to obtain their views on the effects of lifting the ban. We also conducted statistical analyses of the effects of lifting the export ban on the prices of key petroleum products used by West Coast consumers. These analyses were similar to those used to determine the effects of lifting the ban on oil prices. Furthermore, to review the effects of oil exports on the U.S. oil-shipping industry, we talked to Alaskan North Slope oil industry officials, tanker fleet operators, shipbuilding and ship repair industry officials, maritime union representatives, state environmental groups, and state and federal officials. We contacted federal agencies, including the U.S. Maritime Administration and U.S. Coast Guard within the Department of Transportation and the U.S. Customs Service. We also interviewed state officials in Alaska, California, Oregon, and Washington State, and industry officials in these states (including officials with oil companies that refine oil in Hawaii) and in Washington, D.C. From these officials, we obtained and analyzed selected data and records to understand trends in the Alaskan North Slope shipping, shipbuilding, and ship repair industries and to identify the impact of oil exports on these industries.

In addition, where applicable, we applied established economic concepts and theories to predict the likely effects on Alaskan North Slope and California crude oil production in the future. When important price, production, refining, and shipping data were unavailable because they were proprietary, we attempted, to the extent possible, to obtain such information from alternative sources. However, because of proprietary

data limitations, we were unable to determine the full effects of lifting the export ban on cost increases for refiners using Alaskan North Slope or comparable California oil or on the U.S. West Coast market in general.

We provided a draft of this report to the Department of Energy, including its Energy Information Administration and Office of Policy, for review and comment. We discussed the report with Energy Information Administration officials, including the Director, Petroleum Division, and Office of Policy staff. While the Department did not take a position on the findings presented in the report, it provided clarifying comments that we incorporated, where appropriate.

We conducted our work from July 1998 through June 1999 in accordance with generally accepted government auditing standards.

# Lifting the Export Ban Increased Oil Prices and Should Increase Future Oil Production

Lifting the export ban raised the prices of Alaskan North Slope and some California oils between $.98 and $1.30 higher per barrel than they would have been had the ban not been lifted. To date, these price increases have not had an observable effect on Alaskan North Slope and California crude oil production. Nevertheless, future oil production should be higher than it would have been had the ban not been lifted because higher crude oil prices have given producers an incentive to produce more oil. According to oil industry officials, new oil fields developed in Alaska since the ban was lifted are expected to increase Alaskan North Slope oil production by an average of 115,000 barrels per day for the next two decades. However, we could not separate the effects of lifting the ban on expected production from the effects of broader oil market changes occurring at the same time. For example, relatively high world oil prices in 1996 and 1997 encouraged oil producers to expand exploration and development, while low prices in 1998 caused producers to close wells and reduce development. Moreover, this expected production increase will not reverse the decade-long decline of Alaska and California oil production, which is expected to continue as aging oil fields become depleted.

## Prices of Some West Coast Oil Rose as a Result of Lifting the Ban

While world oil prices have been volatile since the export ban was lifted, the price of Alaskan North Slope and some California oil sold in the West Coast market is higher than it would have been had the export ban not been removed. Allowing exports to Asia meant increased demand for Alaskan North Slope oil and higher prices. To determine the effect of lifting the ban on oil prices, we developed a time-series model. Because oil prices are influenced by many factors other than removing the ban, we had to control for these other factors. We did this by modeling the differences between the prices of West Coast oils and the prices of similar oils in other markets. Our analysis indicates that the market price of Alaskan North Slope oil rose compared with the prices of three oils--Brent Blend, Nigerian Forcados, and West Texas Intermediate.[1] The price increase for Alaskan North Slope oil relative to these three oils ranged from $0.98 to $1.30 per barrel.

The effect of lifting the ban on California oil prices depends on the type of oil examined. Light-weight oil with a low sulfur content is higher quality

[1] Brent Blend and West Texas Intermediate oils are widely traded oils and are commonly used as benchmarks for the purpose of comparing other oils and for setting prices. Nigerian Forcados oil is similar in characteristics to Alaskan North Slope oil.

and more valuable than heavy oil with high sulfur content because high-quality oil costs less to refine into gasoline and other light petroleum products. Alaskan North Slope oil is lighter weight and has a lower sulfur content than most California oils. Our analysis indicates that the price of "Line 63" oil in California, which is similar in quality to Alaskan North Slope oil, rose by $1.28 per barrel compared with the price of West Texas Intermediate oil as a result of lifting the ban. However, the effect of lifting the ban on the prices of two other Californian oils we examined (Kern River and THUMS) was insignificant. These two oils are heavy in contrast with Alaskan North Slope and Line 63 oil, which may explain why their prices did not respond to the removal of the export ban in the same way. Appendix II explains the methodology we used to estimate these price increases as well as the economics explanation for why oil prices were expected to increase when the ban was lifted.

## Shipping Costs Are Lower for Exported Oil

Lifting the export ban also resulted in lower shipping costs for oil exported to Asia. For example, total transportation cost in 1996 for oil sold in Asia was about $4.51 less per barrel than for oil sold on the U.S. Gulf Coast. Overall, shipping costs fell by at least $15 million in 1996, $28 million in 1997, and $22 million in 1998 from what they would have been had oil not sold in the West Coast market continued to go to other domestic markets. Like higher oil prices, lower shipping costs improve oil companies' incentives to produce more oil.

Table 2.1 shows the differences in length of tanker voyages, pipeline tariffs, and total transportation costs per barrel for oil shipped from Valdez, Alaska, to Asia and the U.S. Gulf Coast, the U.S. Virgin Islands, and the Mid-Continent in 1996.[2] As the table shows, an average tanker trip to Asia took 30 days, while the average trip to the Gulf Coast took 41 days. In the case of oil sold in the Gulf Coast and the Mid-Continent, shippers paid pipeline tariffs in addition to tanker costs.[3] The additional pipeline tariff was approximately $0.82 per barrel for Gulf Coast shipments and $2.17 per barrel for Mid-Continent shipments. U.S. Virgin Islands shipments went by

[2] For the purposes of this report, the Mid-Continent includes Indiana, Illinois, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin.

[3] Oil destined for the U.S. Gulf Coast was typically taken by tanker from Valdez, Alaska, to the Pacific side of Panama and then transported by pipeline to the Atlantic side of Panama, where it was reloaded onto tankers for the trip to its final destination, such as Louisiana. Shipments to the Mid-Continent went from Valdez to Los Angeles and from there by pipeline to their final destinations.

tanker from Valdez around Cape Horn. This route took an average of 84 days, or about twice as long as the next shorter route. However, the shipping costs to the U.S. Virgin Islands were slightly lower than for the much shorter journey to Asia because the oil companies used larger foreign tankers with foreign crews to transport the oil to the U.S. Virgin Islands.[4] Foreign tankers are much less costly to build, and operating costs for foreign-crewed vessels are lower than for U.S.-crewed vessels. Although the 1995 law does not prohibit exports on foreign-built tankers, all shipments of Alaskan North Slope oil other than to the U.S. Virgin Islands have gone on U.S.-crewed tankers.[5] Table 2.1 also shows the average costs for West Coast shipments in 1996. As the table shows, the West Coast is the lowest cost destination for Alaskan North Slope oil.

**Table 2.1: Cost to Ship Alaskan North Slope Oil, by Destination, 1996**

| Destination | Tanker days | Pipeline tariff per barrel | Cost per barrel |
|---|---|---|---|
| Asia | 30 | $0.00 | $2.64 |
| Gulf Coast | 41 | $0.82 | $7.15 |
| Virgin Islands | 84 | $0.00 | $2.35 |
| Mid-Continent | 16 | $2.17 | $3.80 |
| West Coast | 5-18[a] | $0.00 | $1.63 |

Note. The cost figures are from 1996, the last year of sales to the Gulf Coast and the only year in which sales to Asia coincided with sales to the other destinations shown.

[a] Shipments to Nikiski, Alaska, and Hawaii took 5 and 18 days, respectively. Shipments to all other West Coast destinations took between 6 and 17 days.

Sources: BP-Amoco, U.S. Maritime Administration, and Alaska Department of Natural Resources.

[4] To date, oil companies have used U.S.-built and U.S.-crewed tankers to export oil to Asia.

[5] One exporter told us that while shipping costs to the U.S. Virgin Islands were lower than to Asia, sales to Asia are still more profitable than sales to the U.S. Virgin Islands because the price paid by the Islands refiner was below the price paid in Asia. This exporter told us that its revenue minus shipping costs is between $1 and $2 per barrel higher for Asian sales than for sales to the U.S. Virgin Islands.

## Improved Economic Conditions Have Had No Observable Effect on Oil Production to Date

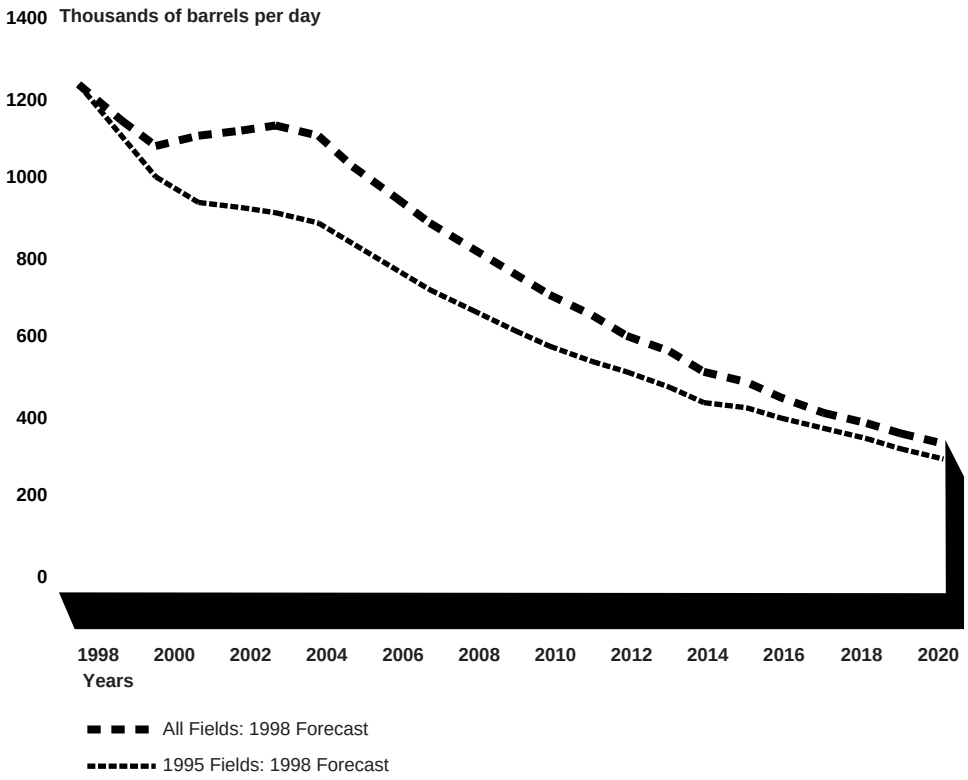
Higher market prices for Alaskan North Slope oil and lower shipping costs for exported oil have given oil producers incentive to produce more crude oil. To date, however, this incentive has not had an observable effect on Alaskan North Slope or California crude oil production. Oil industry officials told us that any effects on production would not occur immediately. There is a lag between the time producers begin to receive higher prices for Alaskan North Slope oil and the time it takes for additional development activities to produce more oil.

## Future Oil Production Should Be Higher as a Result of Lifting the Ban

Oil companies began developing several new fields after the export ban was lifted, and production from these fields is projected to add significantly to future Alaskan North Slope production. Figure 2.1 shows the expected impact—starting in 1999—of the development of new fields since the export ban was lifted on production levels. The bottom line in the figure shows the current projected production of fields that existed prior to the lifting of the export ban. The top line shows the current projected production of all fields--including those that were developed and those for which development has been planned and approved—since the export ban was lifted. The additional projected production between 1999 and 2020 from these new fields is about 115,000 barrels per day, on average. Some oil industry officials told us that some of these new developments were in

response to the removal of the export ban, while others said it was difficult to point to one factor to explain the change.

**Figure 2.1: New Fields Will Add to Daily Alaskan North Slope Oil Production**




Source: Alaskan Department of Revenue, Revenue Sources Book: Forecast and Historical Data, Fall 1995 and 1998.

We found no evidence of a similar increase in oil production in California. Overall oil production in California has continued to decline in the years since the ban was lifted, and we did not observe an expansion of development activity. While an increase in the market price of some California oils would be expected to lead to increased levels of production, none of the oil producers contacted said they had increased their production as a result of lifting the ban.

We could not separate the effects of lifting the export ban on expected production increases from the effects of broader oil market changes

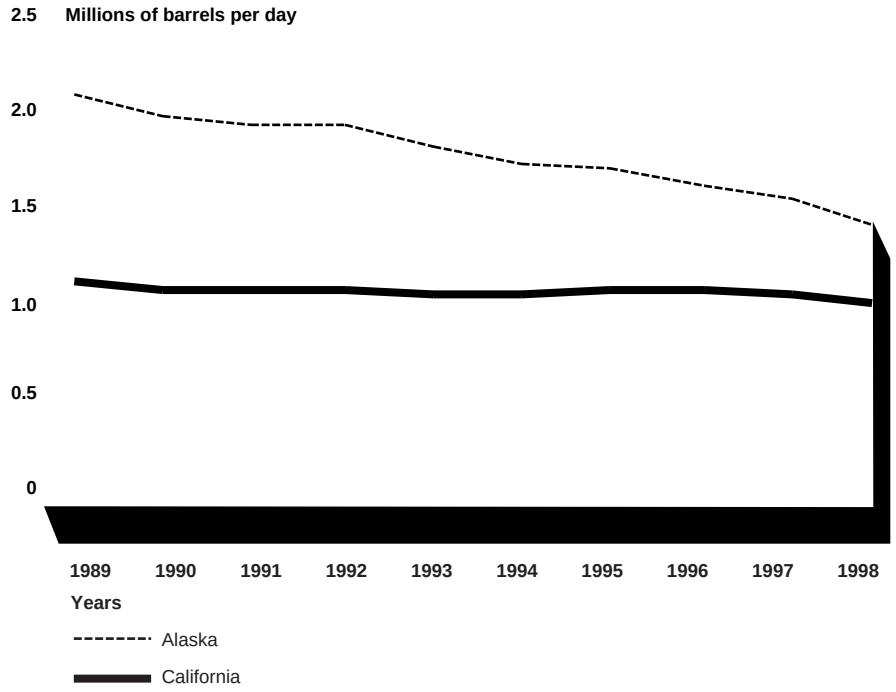
occurring at the same time. Among the other factors positively affecting production decisions were generally high oil prices in 1996 and 1997 and improvements in oil exploration and recovery technology. Higher oil prices encourage greater investment in production and exploration. Average market prices for Alaskan North Slope oil in 1996 and 1997 were $17.74 and $20.90 per barrel, respectively, compared with $15.86 in 1998. Similarly, improved production and exploration technology has lowered production costs, providing greater incentive to produce more oil. More recently, low oil prices in 1998 caused California oil producers to close some oil wells to avoid maintenance costs. The low prices also caused Alaska oil producers to delay planned investments and development. Oil company officials, government analysts, and industry experts told us that separating the effects of lifting the export ban from such other factors is difficult if not impossible.

## Despite Increases in Future Oil Production, the Long-Term Production Decline Will Continue

The expected increase in Alaskan North Slope oil production from lifting the ban will not reverse the long-term decline in oil production in Alaska and California as aging oil fields in these states become depleted. As shown in figure 2.2, crude oil production in both Alaska and California decreased almost every year from 1989 through 1998. During that period, Alaska production decreased by about 35 percent, or about 696,000 barrels per day, primarily because increased production in new, relatively small oil fields did not offset decreased production in large aging fields. New fields and fields that had been closed but were reopened during that period added about 236,000 barrels per day in 1998, which was less than the production decrease in the Prudhoe Bay field, the oldest and largest oil field on the Alaskan North Slope. By 1998, the Prudhoe Bay field was about 74-percent depleted, and production was about half the 1989 level—about 713,000 barrels per day versus about 1.43 million barrels per day. California production also decreased by about 9 percent during that period, or about 94,000 barrels per day, because production in new fields did not offset

decreased production from aging fields. Low oil prices in 1998 also discouraged California production.

**Figure 2.2: Annual Alaska and California Crude Oil Production, 1989-98**




Source: Alaska Department of Revenue and California Department of Conservation.

## State Oil Revenues Were Affected

Alaska revenue rose because of the higher market prices and lower shipping costs that resulted from lifting the export ban. Alaska's petroleum revenue comes from severance taxes, royalties, corporate income tax, property tax, and petroleum rent and lease bonuses. Royalty, severance tax, and income tax revenue are based on the value of oil after excluding pipeline tariff and transportation costs. In April 1998, the Alaska Department of Revenue estimated that the annual increase in revenue resulting from higher West Coast market prices for Alaskan North Slope oil was $40 million. The officials also estimated that the annual increase in

revenue from lower shipping costs to Asia was $10 million. These effects were the direct result of lifting the export ban.

California revenue comes from a share of federal royalties, income taxes, and property taxes. California officials told us that they receive relatively little revenue from these sources. Consequently, there was no significant change in revenue as a result of lifting the export ban.

# Effects of Lifting Oil Export Ban on Refiners, Consumers, and Oil Shipping Industry on the West Coast Have Generally Been Limited

Lifting the oil export ban has had limited effects on refiners, consumers, and the oil-shipping industry—including Alaskan North Slope fleet operators, shipbuilders, and tanker repair yards. Higher market prices for Alaskan North Slope and some California oil increased some refiners' costs but had no or an unclear effect on other refiners' costs. Despite higher crude oil costs for some refiners, West Coast consumers appear to have been unaffected by lifting the ban because the prices of important petroleum products they use have not increased. There have also been minimal effects on the shipping industry to date, although shipbuilding and repair industry officials are concerned that business may shift in the future to low-cost foreign shipyards.

## Some Refiners' Crude Oil Acquisition Costs Rose, but the Extent Is Uncertain

While higher prices for Alaskan North Slope and comparable California oil increased the costs of some individual refiners, we could not determine the extent of the cost increase for these refiners or for the West Coast market in general. Proprietary data needed to make the determination were not available. The impact of rising costs on refiners depends on their ability to pass these costs on to consumers by raising the prices of the petroleum products they sell.

Higher market prices for Alaskan North Slope and comparable California oil translate directly into higher costs for refiners buying this oil on the market. However, not all refiners are affected equally. We looked at three hypothetical cases. First, a refiner buying large volumes of Alaskan North Slope and comparable California oil would experience cost increases when the prices of such oil rise. In the case in which a refiner buys nothing but this oil and always at the market price, costs would rise by exactly the amount the price increased as a result of lifting the ban—about $.98 to $1.30 per barrel on the basis of our analysis. Second, the costs for a refiner buying little or no Alaskan North Slope or comparable California oil would be largely unaffected by increases in the market prices of this oil. Finally, for some refiners that refine mostly oil that comes from their own companies' wells, the effect of the increase in the market price of the oil they produce and refine is unclear because their oil is not sold in the market.

Data on refiners' crude oil purchases and the prices paid are unavailable because they are proprietary. Therefore, we could not determine the increase in refiners' costs because of higher Alaskan North Slope and California oil prices that resulted from lifting the ban. Some refiners we contacted said they pay higher prices for this oil, some said they were

unaffected, and others said it was analytically impossible to determine the effect. However, none of the refiners shared specific cost data with us.

The extent to which refiners can pass higher costs on to consumers determines how their profits are affected by increased crude oil prices. The ability of West Coast refiners to pass rising crude oil costs on to consumers may be constrained by competitive oil market conditions. All refiners were not affected equally by increasing oil costs. Therefore, those refiners whose costs increased the most may not be able to increase their product prices to fully recoup the costs without losing sales to those refiners whose costs did not rise by as much. Increases in crude oil costs not passed on to consumers in the form of higher prices will reduce profit margins for refiners. West Coast refiners we contacted did not reveal the extent to which they passed on increased acquisition costs for crude oil to consumers.

## Consumers Were Not Significantly Affected by Lifting the Export Ban

We analyzed the differences between the prices of West Coast petroleum products and the prices of the same products in other U.S. markets. Our analysis indicates no significant changes in the prices of regular unleaded gasoline, diesel, and jet fuel as a result of lifting the export ban. In 1998, these three products accounted for more than 80 percent of the total output of West Coast refineries, as well as the bulk of consumers' expenditures on petroleum products. These products were chosen because they are good indicators of any potential change.

## Exports Have Had a Limited Effect on Alaskan North Slope Oil Shipping

Lifting the oil export ban has had a limited effect on the Alaskan North Slope oil tanker fleet, the U.S. shipbuilding industry, and the West Coast tanker repair industry. Overall, most tankers carrying Alaskan North Slope oil continue to take the oil to the U.S. West Coast, and the demand for U.S. tankers to transport Alaskan North Slope oil has continued to decline, although exports have slightly offset the decline. Foreign-built tankers have not been used to export Alaskan North Slope oil, and U.S. shipbuilders have not lost orders for new tankers to foreign shipyards. Furthermore, there has not been a trend toward more foreign repairs of Alaskan North Slope tankers since exports began. Nevertheless, U.S.

shipbuilding and West Coast repair yard officials are concerned that they may lose future business to foreign shipyards in part because of oil exports.

## Effects on Tankers Transporting Alaskan North Slope Oil Have Been Limited

Lifting the oil export ban has not greatly altered the number and routes of tankers used to transport Alaskan North Slope oil to date. While the 1995 law that lifted the ban does not require companies to use U.S.-built tankers for export shipments, the fleet serving the Alaskan North Slope remains basically domestic, both in vessel registration and shipment destinations. Moreover, this fleet is almost entirely owned by, or under long-term-charter to, the major Alaskan North Slope oil producers. The number of tankers used to transport Alaskan North Slope oil from Valdez has been decreasing steadily in the 1990s, as a result of the downward trend in Alaska oil production. In 1998, the Valdez fleet had 30 tankers, compared with over 50 in 1990.

Lifting the ban has not significantly altered Alaskan North Slope shipping operations. Most of the oil produced continues to be shipped to West Coast refineries. A small percentage—about 5 percent—of the oil has been exported since the export ban was lifted. The major oil producers in Alaska ship most of their oil to West Coast states, particularly Washington and California—to refineries around Puget Sound, San Francisco, and Los Angeles. In 1998, the average volume shipped to West Coast refineries was a little over one million barrels per day, carried by 30 tankers in 465 shipments. In comparison, only one major producer—BP-Amoco—has been a significant exporter. Since exports began in May 1996, it has exported an average of about 60,000 barrels per day. For example, in 1998, five different tankers chartered to BP-Amoco took a total of 20 shipments to Korea, China, Japan, and Taiwan. An Exxon tanker also took one shipment to Japan in 1997 and one in 1998. Recent trends in major destinations and volumes shipped are shown in table 3.1.

(continued)

**Table 3.1: Destinations of Alaskan North Slope Oil Tankers and Volumes Carried, 1994-98**

Thousands of barrels per day

| Destination | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|
| California/Washington | 1,279 | 1,229 | 1,205 | 1,113 | 1,026 |
| Hawaii | 53 | 49 | 50 | 39 | 43 |
| Alaska | 28 | 32 | 34 | 36 | 26 |
| U.S. Gulf Coast via Panama | 75 | 62 | 4[a] | 0 | 0 |
| U.S. Virgin Islands[b] | 95 | 88 | 48 | 5[a] | 0 |
| Asia | 0 | 0 | 36[a] | 68 | 53 |
| **Total** | **1,530** | **1,460** | **1,377** | **1,261** | **1,149[c]** |

[a] On a full-year basis; for the partial year during which oil was shipped, per-day volume was higher.

[b] All shipments were made on foreign-flagged tankers.

[c] Does not add due to rounding.

Source: U.S. Maritime Administration.

As shown in table 3.1, the volume of oil shipped to Washington/California and Hawaii has decreased gradually in recent years, while the volume shipped to Alaska increased from 1994 through 1997, then decreased in 1998. At the same time, the volume shipped to the U.S. Gulf Coast via Panama and to the U.S. Virgin Islands around Cape Horn fell to zero after the export ban was lifted. According to federal maritime and industry officials, both the U.S. Gulf Coast and U.S. Virgin Islands destinations were declining even without the influence of exports because, compared with U.S. West Coast destinations, they involve high shipping costs, especially the shipments to the U.S. Gulf Coast. Some officials said that export shipments in effect replaced the trade with the U.S. Virgin Islands and accelerated its end.

Exports have affected some tanker operators more than others. Officials of ARCO and Exxon, which have subsidiaries that own and operate tankers in the Alaskan North Slope trade, said that because they have made few, if any, export shipments, lifting the export ban has had little or no effect on their Alaskan North Slope tanker fleets. However, officials of BP-Amoco (which is not a U.S.-owned corporation and therefore is not permitted to own tankers engaged in the U.S. domestic trade) said that exports to Asia allow the company to lower its transportation costs and thus provide an important new market. In addition, officials of the charter shipping companies that carried exports for BP-Amoco said that the export legislation benefited their business. These officials said that exports have

slightly increased the demand for U.S. tankers to carry Alaskan North Slope oil. According to officials of two companies, because of exports, a few of their tankers that might otherwise have been unused were active in the Alaskan North Slope fleet. Our analysis confirmed that while overall fleet size continues to decrease, exports may have slightly increased the demand for U.S. tankers in the Alaskan North Slope trade in 1996 and 1997.

Exports have led to the disappearance of foreign-registered tankers from the Alaskan North Slope fleet and may therefore have caused an increase in jobs for U.S.-tanker crews. Foreign tankers with foreign crews carried Alaskan North Slope oil from Valdez to the U.S. Virgin Islands under a long-standing exception in the Jones Act. As shown in table 3.1, before the ban was lifted, oil was shipped from Valdez around Cape Horn to refineries in the U.S. Virgin Islands. Several foreign-registered, foreign-crewed tankers made these trips. According to our analysis, lifting the ban caused these foreign tankers and crews to be replaced by U.S.-crewed tankers going to Asia. Tankers carrying Alaskan North Slope oil from Valdez to Asia to date have been U.S.-documented (including U.S.-registered and U.S.-crewed) and U.S.-owned, as required by the 1995 legislation that lifted the export ban. As a result of this change in destinations, the equivalent of one or two additional U.S. tankers were used to carry Alaskan North Slope oil in 1996 and 1997, creating an estimated 58 to 115 U.S. tanker crew jobs.[1] These jobs partially offset the overall decrease in U.S. tanker crew jobs in the Alaskan North Slope trade during the past decade caused by declining crude oil production and fleet size.

## Effects on U.S. Shipbuilding Have Been Limited

To date, lifting the oil export ban has also had a limited effect on the U.S. shipbuilding industry. Demand for new tankers for the Alaskan North Slope trade—either U.S. or foreign-built—appears to be minimal at present and driven primarily by factors other than exports. Since the export ban was lifted, Alaskan North Slope tanker operators have had the option of exporting oil in foreign-built tankers, but to date they have not done so. Likewise, U.S. shipyards have not lost orders for new Alaskan North Slope export tankers to foreign shipyards. Although several U.S. shipyards are equipped to build Alaskan North Slope tankers, no U.S. shipyard has delivered one since 1987. According to industry officials, U.S. shipbuilders have been at a price disadvantage in the world commercial shipbuilding

[1] Based on U.S. Maritime Administration estimates of 25 billets per tanker and 2.3 crew members per billet.

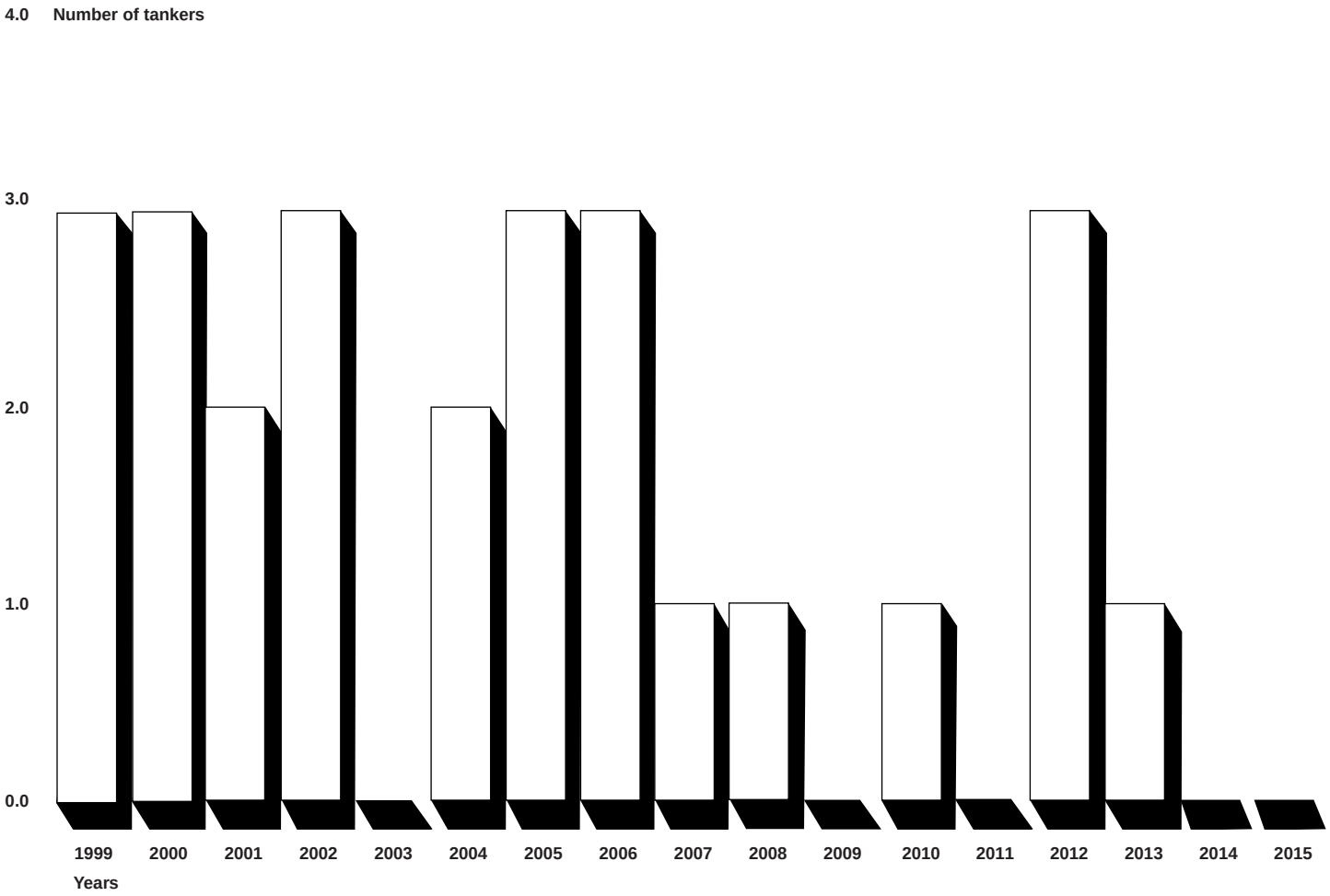
market because of, among other reasons, higher costs and less-modern production methods.

U.S. shipbuilders and other industry officials expected 10 or more new orders in the 1990s for tankers to serve the Alaskan North Slope. These expectations resulted in part from the enactment of the Oil Pollution Act of 1990, in response to the Exxon Valdez accident.[2] The act mandated, among other things, the phaseout of single-hulled tankers and the transition to double-hulled tankers by 2015, in order to reduce the effects of oil spills in the event of accidents. However, only three orders have materialized so far. All three orders were from ARCO for tankers to be built by Avondale, Inc., of Louisiana, and to be delivered between 2000 and 2002. Additionally, a proposed order from BP-Amoco for three tankers to be built by the National Steel and Shipbuilding Company, of San Diego, was deferred indefinitely in October 1998. According to industry officials, factors in the lack of orders to date include falling oil prices in 1998 and their effect on Alaskan North Slope planning and development, as well as the price of new tankers—in some cases up to three times as much in U.S. shipyards compared with overseas yards.

Despite the lack of tanker demand to date, there could be some demand for new Alaskan North Slope tankers in the next decade, according to shipbuilding and oil company officials. As shown in figure 3.1, under Oil Pollution Act of 1990 requirements, 26 Alaskan North Slope tankers are due to be phased out of the fleet by 2015.

[2]On Mar. 24, 1989, the Exxon Valdez ran aground on a reef, spilling about 11 million gallons of Alaskan North Slope crude oil into Prince William Sound.

**Figure 3.1: Number of Alaskan North Slope Tankers Scheduled to Be Phased Out, 1999-2015**




Source: U.S. Maritime Administration.

As shown in figure 3.1, 19 tankers serving the Alaskan North Slope are to be phased out by the end of 2006. Some of these tankers, but not all, would need to be replaced, assuming that Alaskan North Slope production continues to decline. Oil companies would have replacement alternatives to new U.S.-built tankers, including (1) extending the life of existing tankers by converting the hulls and (2) using existing or new foreign-built tankers for exports. Oil company officials told us that their needs for future U.S. tankers will depend on various oil industry and market factors. Although introducing foreign-built tankers into the Alaskan North Slope

trade to carry exports is an option, oil company officials told us they have no plans to do so in the foreseeable future.

Nevertheless, officials in the U.S. shipbuilding industry said they are concerned about losing future Alaskan North Slope tanker orders to overseas shipyards, in part because of exports. They contend that the export option gives oil companies an added incentive to further postpone orders for new U.S.-built tankers. According to these shipbuilding officials, foreign-built tankers to export Alaskan North Slope oil are a possibility within a few years, if not immediately. If so, jobs in U.S. shipyards could be affected. According to company officials, each tanker order postponed or lost to a foreign competitor costs about 1,000 U.S. shipyard jobs for the 18 months it takes to construct a tanker.

In addition, postponed tanker orders contribute to the aging of the Alaskan North Slope fleet, with a potential impact on fleet safety. Because no new tankers have entered the fleet since 1987, half of the fleet consists of single-hulled tankers built in the 1970s or before. Even though the oldest tankers have been phased out of service, the phaseout has been so gradual that, on average, the remaining fleet has gotten older. The average age of the fleet has increased since the Oil Pollution Act of 1990 was passed—from about 16 years old in 1990 to 21 years old in 1998.[3]

## Effects on West Coast Tanker Repair Yards Have Been Limited

The ability to export Alaskan North Slope oil has given tanker operators an added incentive to repair tankers overseas rather than on the West Coast because they can reduce costs by combining oil shipments to Asia with less expensive Asian repairs. However, since the export ban was lifted, there has not been a trend toward more overseas repairs. Tankers serving the Alaskan North Slope undergo major, scheduled "drydock" repairs about twice every 5 years at a cost of $1 million to over $10 million each. A drydock repair can take a tanker out of service for several weeks. Exact information on the number of Alaskan North Slope tanker repairs for recent years was unavailable. However, according to data supplied by industry officials, and on the basis of recent fleet size, we estimate that

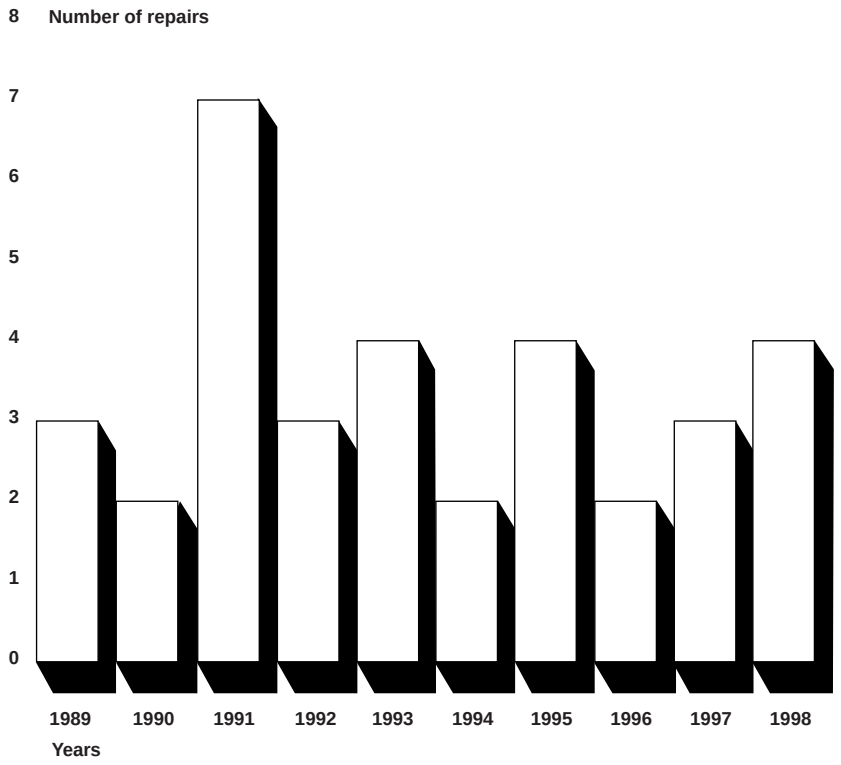
[3] The 1990 fleet included four tankers rebuilt in 1983 or earlier and the 1998 fleet included three such tankers.

about 10 to 15 such repairs have occurred annually for tankers serving the Alaskan North Slope in recent years.

On average, repairs have been decreasing in the 1990s at a rate that is commensurate with the decline in Alaskan North Slope production and fleet size. Three West Coast repair yards, in California, Oregon, and Washington State, compete with several Asian yards for the Alaskan North Slope tanker repair business. These West Coast yards are situated near Alaskan North Slope shipping lanes and destinations. However, according to industry officials, the U.S. repair yards are at a competitive disadvantage because Asian yards may charge less than half of what a U.S. yard would charge for a comparable tanker repair.

Combining an oil shipment to Asia with a less expensive Asian repair allows tanker operators to avoid the extra cost of going without oil cargo to Asia for a repair. Overseas repairs of U.S. ships are subject to U.S. Customs duties of 50 percent of certain repair costs levied on the vessel operator. According to U.S. Customs and shipping industry data, overseas repairs of Alaskan North Slope tankers have not increased significantly since the ban was lifted, as shown in figure 3.2.

**Figure 3.2: Number of Overseas Repairs of Alaskan North Slope Tankers, 1989-98**




Source: U.S. Customs Service.

As shown in figure 3.2, overseas repairs of Alaskan North Slope tankers have averaged between three and four a year. No significant trend toward more overseas repairs has developed since exports began. Of the nine total overseas repairs since 1996, seven involved the tankers of one oil company that has historically repaired its tankers overseas and has not been an exporter of Alaskan North Slope oil.

Officials of the West Coast tanker repair industry said that their recent experience raised concerns that a trend toward more foreign repairs of Alaskan North Slope tankers could be beginning to develop, with exports as a contributing factor. They cited two foreign repairs of Alaskan North Slope tankers in Asia in 1998. In one of these cases, a tanker that transported crude oil to Korea underwent a scheduled drydock repair in a Korean shipyard before returning to the United States. According to West Coast repair industry officials, this case illustrates how exports may be

starting to harm the West Coast ship repair industry. In the other case, the tanker went without cargo to Singapore for a scheduled drydock repair. According to operators involved in the two cases, a major factor in having repairs done overseas was the significantly lower cost in Asian repair yards compared with U.S. West Coast yards, even when U.S. Customs duties are added and even without carrying cargo, as in the latter case. According to West Coast repair industry officials, the two lost repairs represented several million dollars in business and potential lack of employment for over 500 workers a day for each repair.

# Lifting the Oil Export Ban Has Had Little Impact on the Alaskan Environment

According to our discussions with Alaskan North Slope oil industry officials, state of Alaska officials, and environmental groups, lifting the export ban has had little effect on the Alaskan environment to date. Their opinions are based in part on the fact that export shipments from 1996 to 1998 were more limited than projected by some analysts. Export shipments have not resulted in the use of larger tankers or new, potentially more hazardous shipping routes to Asia and have not significantly increased the risks of invading nonindigenous marine species, such as plankton and other organisms, into Alaskan waters.

Prior to lifting the oil export ban, according to some projections, exports of 200,000 barrels of oil per day or more were to be carried in Alaskan North Slope tankers that were of larger than average size—vessels with a capacity of 200,000 deadweight tons or more.[1] In addition, some environmentalists foresaw the use of new, potentially more hazardous shipping routes to Asia along the Aleutian Islands coast instead of in deep water. However, this projected new tanker traffic has not materialized. There have been a relatively small number of export shipments to date—a total of 21 in 1998, for example–and existing tankers have been used. In addition, export tankers have been avoiding near-Aleutian routes in favor of already existing routes for which contingency planning and spill response teams are already in place. Furthermore, officials for the oil industry, Aleyska Pipeline Service Company (the organization that operates the Trans-Alaska Pipeline System), and U.S. Coast Guard said that they have not changed their operations as a result of the ban's being lifted. Rather, any changes made resulted from the Exxon Valdez accident in 1989. The existing routes involve escorted transits out of Prince William Sound into deeper ocean, where tankers then head toward the U.S. mainland, Hawaii, or Asia.

Nonindigenous marine species may come to Alaska in a tanker's ballast water, which is routinely exchanged (taken on board and/or discharged from the vessel) either in port or under way, in order to maintain vessel stability. Potentially invasive species include plankton, crustaceans, and other organisms that could disturb the local marine ecology. However, the export-related invasion of Asian marine species does not appear to be a significant problem to date. Alaska officials and two representatives of an environmental group told us that this is an issue in Alaska, but not necessarily because of Alaskan North Slope oil exports. According to oil company officials, the operators of export tankers have added a second

[1] Deadweight tons are a measure of a ship's cargo capacity.

mid-ocean ballast water exchange while under way toward Valdez in addition to the one exchange required by federal law—the National Invasive Species Act of 1996. They said this step helps to avoid the invasion of nonindigenous species. In addition, according to an interim report commissioned by the Regional Citizens' Advisory Council of Prince William Sound, species in ballast water from Asia may not as readily occur or survive in Alaskan waters as species from Washington and California ports.[2] A final report on this matter is due to be issued later in 1999.

[2]Biological Invasion of Cold-Water Coastal Ecosystems: Ballast Mediated Introduction in Port Valdez/Prince William Sound, Alaska—1998 Progress Report, Dec. 3, 1998, for Regional Citizens' Advisory Council of Prince William Sound.

# Methodology for Estimating the Effect of Lifting the Alaskan Oil Export Ban on Crude and Petroleum Product Prices

This appendix provides details on the statistical analysis we used to explain and estimate how lifting the ban on Alaskan oil exports has affected crude oil and petroleum product prices on the U.S. West Coast. We conducted statistical analyses using data on oil prices before and after the ban was lifted to determine whether the effects on price predicted by previous studies were borne out. We used a similar analysis to determine what effect the ban's lifting had on the prices charged for gasoline, diesel, and jet fuel on the West Coast.

In summary, our statistical analysis indicates that lifting the export ban led to relative prices for Alaskan crude oil and for comparable California crude oil that were higher than they would have been had the ban remained in force. However, lifting the ban had no statistically significant effect on the prices of gasoline, diesel, or jet fuel. These results are consistent with predictions of earlier studies. In addition, we found that sales of Alaskan crude oil destined for the U.S. Virgin Islands and the U.S. Gulf Coast ended and sales to the Mid-Continent fell abruptly once exports became a feasible alternative. Relatedly, we found that the proportion of Alaskan oil sold on the West Coast has risen over time as Alaskan and California production have fallen.

## Prior Studies Found That the Ban Resulted in Lower Oil Prices

Several analyses by the Department of Energy, GAO, and the private sector found that West Coast prices of Alaskan oil were lower as a result of banning exports of this oil.[1] These studies concluded that this ban resulted in an abundance of crude oil relative to refining demand on the West Coast, leading to lower crude oil prices there. The studies contend that lifting the export ban would result in Alaskan oil being sold in Asian markets, causing its price to rise on the West Coast. Because California oil is also refined on the West Coast, higher Alaskan prices would tend to increase refiners' demand for California oil, pushing up its price as well. The effects of lifting the ban on oil production, refining costs, and consumer prices were also predicted in these studies. For example, higher oil prices were expected to encourage more oil production while also leading to higher costs for refiners buying that oil and possibly higher prices for consumer petroleum products.

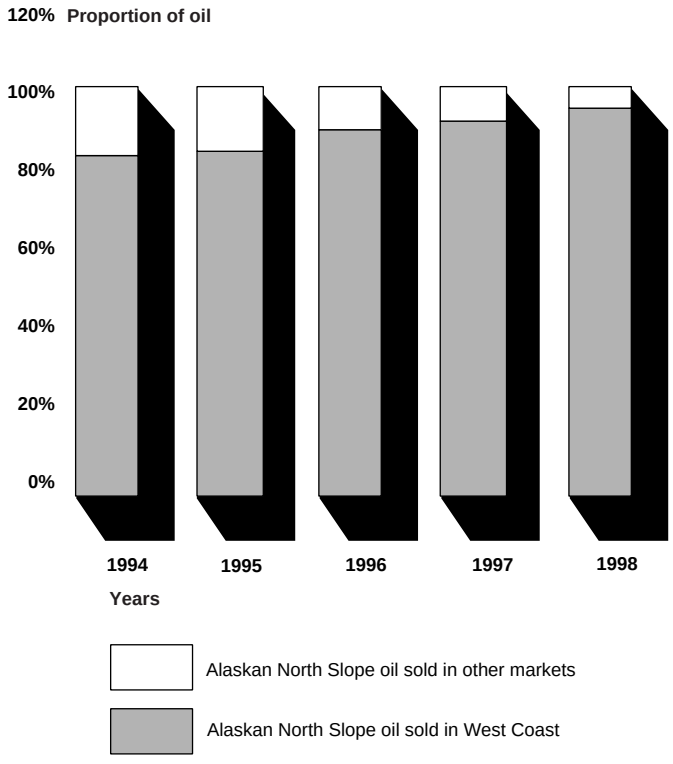
[1] Exporting Alaskan North Slope Crude Oil: Benefits and Costs, U.S. Department of Energy (June 1994), Alaskan Crude Oil Exports (GAO/T-RCED-90-59, Apr. 5, 1990) , and Samuel A. Van Vactor, Time to End the Alaskan Oil Export Ban, Policy Analysis, May 18, 1995, No. 227.

## Alaskan Oil Is No Longer Sold in the U.S. Gulf Coast and U. S. Virgin Islands

Sales of Alaskan oil to the U.S. Gulf Coast ended about 5 months before the first exports to Asia, and sales to the U.S. Virgin Islands ended about 8 months later. Sales to the Mid-Continent states dropped off abruptly when the ban was lifted. Before the ban was lifted, total sales to these markets were falling as Alaskan oil production fell from its peak in 1988. Whether the lifting of the ban, rather than falling production, caused the cessation of sales to the Gulf Coast and Virgin Islands is unclear. However the abrupt drop in sales to the Gulf Coast, Virgin Islands, and Mid-Continent states coincided with the ban's removal.

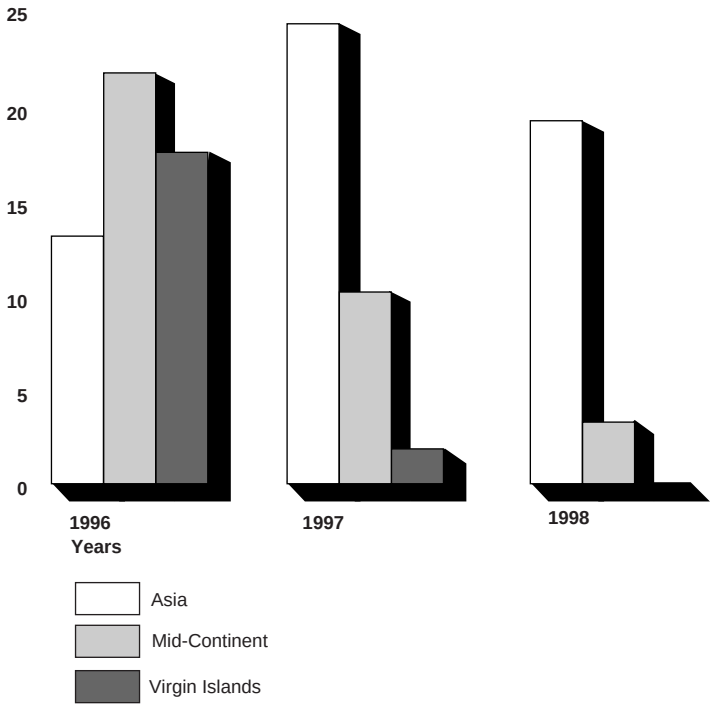
Figures II.1 and II.2 illustrate the observations listed above. As production has fallen, the proportion sold to West Coast refiners has risen, and sales to alternative markets have declined. Finally, since the ban was lifted, some sales to these other markets have been replaced by Asian sales.

**Figure II.1: Proportion of Alaskan North Slope Oil Sold in the West Coast Market**




Source: U.S. Maritime Administration Vessel Loading and Destination reports.

**Figure II.2: Alaskan North Slope Oil Destinations Other Than the West Coast**




Note: The 1996 figures for Asia are for May 31 through December 31, corresponding to the period in 1996 during which oil was exported to Asia.

Source: U.S. Maritime Administration Vessel Loading and Destination reports.

## Statistical Analysis Indicates That Lifting the Ban Resulted in Higher Prices for Alaskan and Comparable California Oil

As predicted by the studies described above and as we found in our analyses of the prices of oil before and after the ban was lifted, the price of Alaskan North Slope oil has risen relative to other oil as a result of lifting the export ban. We also found that the price of a comparable blend of California oil--Line 63--rose as a result of lifting the ban.

To determine the effect of lifting the ban on oil prices, we developed a time-series model. Because oil prices are influenced by many factors other than removing the ban, we had to control for these other factors. We did this by modeling the differentials between the prices of West Coast oil and the prices of similar oil in other markets. Modeling the price differentials

between two crude oils is a way to control for all the factors that affect the two oils similarly—such as changes in global supply and demand—while capturing changes in the local markets of the two oils that affect only one of the oils. To control for local factors affecting the prices of individual comparison oils, we examined three price differentials for Alaskan North Slope (ANS) oil and three for Line 63 (L63). The comparison oils, making up the other part of the differentials are Brent Blend (BB), Nigerian Forcados (FOR), and West Texas Intermediate (WTI). For each of the six differentials, the price differential is defined as the price of the comparison oil minus the price of the West Coast oil—be it Alaskan North Slope or Line 63 oils. We used daily spot price data as reported in *Platts Oil Prices Data Base*. The data series we used run from January 8, 1992 ,through December 4, 1998, and are in nominal dollar terms.[2]

To compare the price differential before and after the export ban was lifted, we included in the regression a dummy variable to indicate when the ban was removed. Diagnostic tests indicated that the price differential series was auto-regressive of order one. Therefore, we included a lagged price differential as a regressor. Diagnostic tests also revealed that the residuals were auto-regressive conditionally heteroskedastic. To correct for this, we included a GARCH(1,1) component to the regression.[3] The estimated form of the equation of the price differential is

$$DIFF_t = \alpha + \beta DIFF_{t-1} + \gamma EXPORT_t + \varepsilon_t,$$

where *DIFF* is the difference between the prices of the comparison and West Coast oils; *EXPORT* is a dummy variable to indicate the removal of the ban; $\alpha$, $\beta$, and $\gamma$ are parameters to be estimated; and $\varepsilon$ is a random error term.[4] The subscript *t denotes time. The parameter $\gamma$ does not measure the marginal effect of lifting the ban on the price differential because of the auto-regressive property of the model.*[5] *The results of maximum likelihood estimation are shown in tables II.1 and II.2.*

[2] We used daily spot price data rather than constructing weekly or monthly averages of this data because we wanted to examine prices that reflect actual transactions. It is possible that using weekly or monthly averages would change the results of the statistical analysis but we did not explore this approach.

[3] The details of the diagnostic tests and the choice of the final form of the regression model are discussed in detail below.

[4] The dummy variable takes on the value of unity for dates on or after May 28, 1996, and is otherwise equal to zero.

**Table II.1: Results of Price Analysis for Alaskan North Slope (ANS) Oil**

| Coefficients | WTI-ANS | BB-ANS | FOR-ANS |
|---|---|---|---|
| CONSTANT | 0.037*<br>(0.003) | 0.019*<br>(0.005) | 0.022*<br>(0.006) |
| $DIFF_{t-1}$ | 0.986*<br>(0.002) | 0.976*<br>(0.003) | 0.982*<br>(0.003) |
| EXPORT | -0.018*<br>(0.004) | -0.024*<br>(0.007) | -0.02*<br>(0.008) |
| **-Γ** | 1.295 | 0.979 | 1.102 |
| Adj. R-Squared | 0.976 | 0.946 | 0.952 |

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5-percent level.

The long-term increase in the relative price of Alaskan North Slope oil relative to the three comparison oils ranges from $0.98 to $1.30 as shown in the -Γ cells. All coefficient estimates are significant at the 5-percent level.

**Table II.2: Results of Price Analysis for Line 63 (L63) Oil**

| Coefficients | WTI-L63 | BB-L63 | FOR-L63 |
|---|---|---|---|
| CONSTANT | 0.051*<br>(0.007) | 0.017*<br>(0.008) | 0.025*<br>(0.009) |
| $DIFF_{t-1}$ | 0.986*<br>(0.003) | 0.987*<br>(0.003) | 0.986*<br>(0.003) |
| EXPORT | -0.018*<br>(0.006) | -0.005<br>(0.009) | -0.012<br>(0.01) |
| **-Γ** | 1.282 | [a] | [a] |
| Adj. R-Squared | 0.975 | 0.956 | 0.959 |

[a] Not applicable. The export coefficient was not significant, so we did not calculate the Γ value.

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5-percent level.

[5] The auto-regressive structure of the model requires that the long-run impact of lifting the ban be calculated as follows:

$$\Gamma = \gamma \frac{1}{1-\beta}$$

where Γ is the long-term effect of lifting the ban on the differential, and γ and β are as defined above. The negative of Γ can be interpreted as the increase in the price of the West Coast oil relative to the comparison oil. These values are listed in tables II.1 and II.2 for the cases in which the *EXPORT* variable was statistically significant.

The price of Line 63 oil rises significantly compared with West Texas Intermediate but does not rise significantly compared with either Brent Blend or Nigerian Forcados. In the latter two cases, the direction of change is the same and the order of magnitude of $\gamma$ is similar to the significant case. However, because the coefficients are not statistically significant, we did not calculate the long-term effect.

## No Effect Found on the Prices of California Heavy Crude Oils

We conducted a similar analysis using the prices of two heavy California oils—Kern River and THUMS—and found no significant changes when the export ban was lifted. We used daily spot price data as reported in *Platts Oil Prices Data Base*. The data series we used run from January 8, 1992, through December 4, 1998, and are in nominal dollar terms. We compared the prices of these two oils to the prices of Duri, Indonesia (DU); Shengli, China (SH); and West Texas Intermediate oils. West Texas Intermediate was chosen to provide some consistency between these and the previous regression results.[6] The other two oils were chosen because, like Kern River and THUMS, they are heavy oils and therefore their prices should be expected to be affected similarly by global market conditions. The regression results follow.

Kern River oil shows no significant change in price compared to any of the comparison oils, as shown in table II.3.

**Table II.3: Results of Price Analysis for Kern River (KERN) Oil**

| Coefficients | WTI-KERN | SH-KERN | DU-KERN |
|---|---|---|---|
| CONSTANT | 0.186*<br>(0.041) | 0.048*<br>(0.013) | 0.0574*<br>(0.014) |
| $DIFF_{t-1}$ | 0.969*<br>(0.006) | 0.984*<br>(0.004) | 0.982*<br>(0.004) |
| EXPORT | -0.013<br>(0.019) | 0.002<br>(0.012) | -0.001<br>(0.013) |
| $-\Gamma$ | a | a | a |
| Adj. R-Squared | 0.917 | 0.958 | 0.952 |

[a]Not applicable. The export coefficient was not significant, so we did not calculate the $\Gamma$ value.

[6] In the case of the WTI-Kern and WTI-THUMS differential models, we also ran regressions that included a world "light-heavy" differential (specifically, Brent Blend and Duri, Indonesia) to control for structural changes in the light-heavy differential in the mid-1990s. Adding this term in the regression did not change the significance of the EXPORT coefficient, so we do not report these results.

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5-percent level.

As with the Kern River results, there was no significant change in the price of THUMS relative to any comparison oil, as shown in table II.4.

**Table II.4: Results of Price Analysis for THUMS Oil**

| Coefficients | WTI-THUMS | SH-THUMS | DU-THUMS |
|---|---|---|---|
| CONSTANT | 0.144*<br>(0.033) | 0.027*<br>(0.01) | 0.031*<br>(0.011) |
| $DIFF_{t-1}$ | 0.97*<br>(0.006) | 0.986*<br>(0.004) | 0.986*<br>(0.004) |
| EXPORT | -0.016<br>(0.018) | -0.005<br>(0.011) | -0.009<br>(0.012) |
| -Γ | a | a | a |
| Adj. R-Squared | 0.913 | 0.956 | 0.95 |

[a]Not applicable. The export coefficient was not significant so we did not calculate the Γ value.

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5-percent level.

## Statistical Analysis Indicates No Effect on the Prices of Petroleum Products

Our analysis of prices of three key consumer products—gasoline, diesel fuel, and jet fuel—indicated that lifting the ban had no statistically significant effect on them. Because higher crude oil prices translate directly into higher refiner costs for refiners, it would not be unusual to find that some of the increase in costs was passed on to consumers in the form of higher prices for petroleum products. However, refiners whose costs rose as a result of removing the ban may not have been able to pass these costs on to consumers because of competition from imported final products or from other West Coast refiners whose costs did not rise.

To determine the effect on petroleum prices of removing the ban, we conducted an analysis of petroleum prices that was similar to the crude oil price analysis described above. We used daily spot price data as reported in *Platts Oil Prices Data Base*. The data series we used run from January 8, 1992, through December 4, 1998, and are in nominal dollar terms. We compared West Coast prices of regular unleaded gas, diesel fuel, and jet fuel with prices of these same products in other markets. The time series of the petroleum product price differentials and the crude oil price differentials behaved similarly, making the same model structure appropriate. Our analysis revealed no statistically significant change in West Coast petroleum product prices that was not explained by similar

changes in the prices of these products in other markets. Specifically, we did not find any change in the prices at the time the ban was lifted, indicated by the absence of a statistically significant estimated β coefficient for the export dummy variable. The results of our regressions are listed in tables II.5 through II.7.

**Table II.5: Analysis of Jet Fuel (JET) Prices**

| Coefficients | LA-CHIJET | SF-CHIJET |
|---|---|---|
| CONSTANT | 0.622*<br>(0.079) | 0.581*<br>(0.081) |
| $DIFF_{t-1}$ | 0.965*<br>(0.005) | 0.966*<br>(0.005) |
| EXPORT | -0.027<br>(0.043) | -0.02<br>(0.045) |
| **-Γ** | a | a |
| Adj. R-Squared | 0.922 | 0.921 |

[a] Not applicable. The export coefficient was not significant, so we did not calculate the Γ value.

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5-percent level.

Lifting the ban had no significant effect on the prices of jet fuel in Los Angeles (LA) or San Francisco (SF) when compared with the price of jet fuel in Chicago (CHI).

**Table II.6: Analysis of Diesel Prices**

| Coefficients | SF-GULFDIESEL |
|---|---|
| CONSTANT | 0.417*<br>(0.083) |
| $DIFF_{t-1}$ | 0.972*<br>(0.005) |
| EXPORT | 0.028<br>(0.051) |
| **-Γ** | a |
| Adj. R-Squared | 0.941 |

[a] Not applicable. The export coefficient was not significant, so we did not calculate the Γ value.

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5-percent level.

Diesel fuel prices in San Francisco were also unaffected by lifting the export ban when compared with diesel prices in the Gulf Coast (GULF).

**Table II.7: Analysis of Gasoline (GAS) Prices**

| Coefficients | LA-GULFGAS | SF-GULFGAS |
|---|---|---|
| CONSTANT | 0.236*<br>(0.029) | 0.101*<br>(0.031) |
| $DIFF_{t-1}$ | 0.961*<br>(0.004) | 0.969*<br>(0.005) |
| EXPORT | -0.011<br>(0.054) | 0.044<br>(0.06) |
| **-Γ** | a | a |
| Adj. R-Squared | 0.934 | 0.94 |

[a] Not applicable. The export coefficient was not significant, so we did not calculate the Γ value.

Note: Standard errors are in parentheses. An asterisk denotes significance at the 5 percent level.

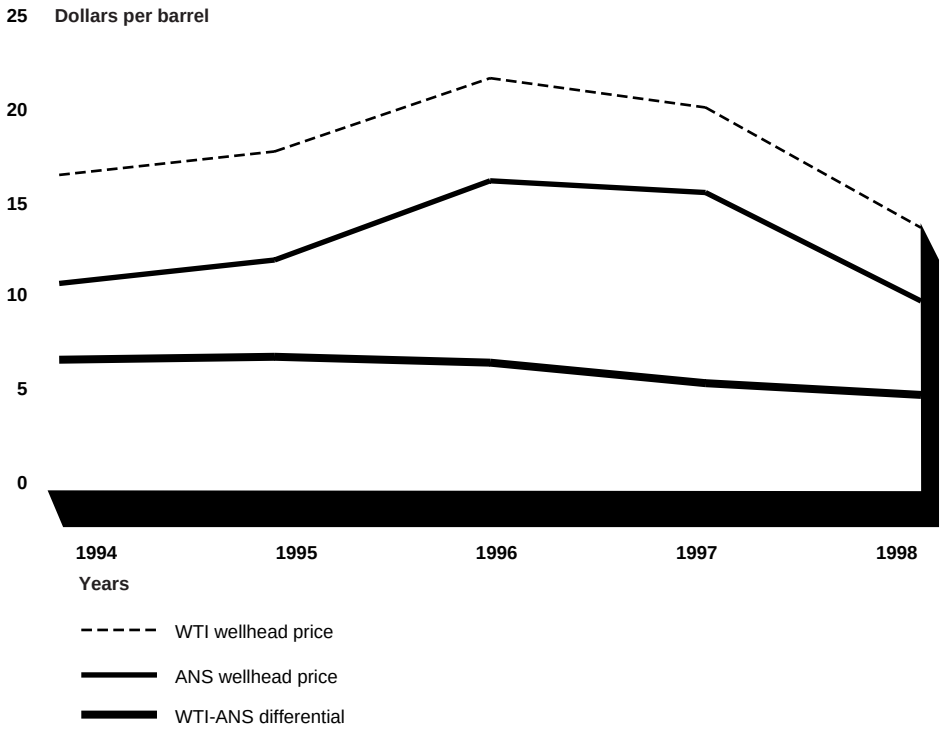
Again, there was no significant change in the West Coast prices of regular unleaded gasoline as a result of lifting the export ban.

## Further Evidence of an Increase in the Price of Alaskan North Slope Oil

Higher market prices for Alaskan North Slope oil and lower shipping costs mean higher revenues for producers of this oil. The impact of lifting the ban on Alaskan North Slope producers' revenues net of transportation costs can be seen in figure II.3. This figure shows the prices received at the "wellhead" for two oils—West Texas Intermediate and Alaskan North Slope—as well as the difference between their respective prices. These so-called wellhead prices reflect the revenue the producer receives net of transportation and shipping costs. Rising market prices for Alaskan North

Slope oil and falling shipping costs both contribute to the shrinking of the gap between the two oils' wellhead prices.

**Figure II.3: ANS Wellhead Price Has Risen Compared With WTI**




Source: GAO's analyses of Energy Information Administration data.

## Tests for Stationarity and Diagnostics: Development of the Correct Statistical Model

To ensure that we estimated the correct model of the price differentials, we checked for stationarity of the price differential time series and did some standard diagnostic testing. These tests helped us to develop the final form of the model and give us confidence that the results of the estimations are not spurious. A detailed description of the development of the model follows.[7]

[7] The process described for choosing the correct statistical model was followed for each oil price differential and for each petroleum price differential.

We chose a period of study of January 8, 1992, through December 4, 1998, and used daily spot prices as reported by *Platts Oil Prices Data Base*. This period was chosen in order to encompass the removal of the export ban with sufficient time on either side of this event. An arithmetic mean of the low and high spot prices was used for the analysis. All tests for stationarity and diagnostics were performed on data prior to May 28, 1996.

The simplest model of the price differential is a standard ordinary least squares (OLS) regression of the price differential on a constant term with a dummy variable to pick up the effect of lifting the export ban. Test statistics derived from an OLS regression of a time series will not be reliable if the time series is not stationary.[8] Therefore, the first step is to test for stationarity of the series of price differentials.

To test for stationarity, we used the Augmented Dickey-Fuller (ADF) test. First, we estimate the following equation using OLS:

$$\Delta PD_t = \alpha + \phi PD_{t-1} + \sum_{j=1}^{\rho} \beta_{t-j} \Delta PD_{t-j} + \varepsilon_t$$

where $PD$ is the difference between the prices of the comparison oil and Alaskan North Slope oil; $\Delta$ is the difference operator; $\alpha$, $\phi$, and $\beta$ are parameters to be estimated; and $\varepsilon$ is a random error term. The subscript $t$ denotes time. The number of lags of $PD$ (denoted by $\rho$) is chosen by starting with a large number of lags and sequentially dropping the statistically insignificant lags from the highest lag down. Lags greater than $\rho$ have a statistically insignificant effect on the regressand.

A test for nonstationarity amounts to a test of the null hypothesis that $\phi$ is equal to zero. If $\phi$ is equal to zero, the time series $PD_t$ has a unit root and will behave analogously to a random walk, which is nonstationary. Alternatively, if $\phi$ is negative and statistically significant, then the time series (expressed as deviations from the mean) will converge to zero in response to shocks. Using the period prior to the lifting of the export ban, the ADF test rejects the null hypothesis of nonstationarity at the 5-percent

[8] A time series is stationary if its mean, variance, and autocovariances are independent of time and nonstationary otherwise. If the price differential we model is stationary, then we would expect to see that the mean of the differential is unchanging over time except when it changes in response to an event, such as the removal of the export ban.

level.[9] We also performed the Phillips-Perron test and were able to reject nonstationarity at the 5-percent level.

Results of these tests indicate that standard regression techniques are appropriate for modeling the price differentials. Next, we performed some diagnostic tests to determine whether lagged values of the differential affect current values. More specifically, we checked the order of the model by examining the correlogram and partial correlogram. The correlogram showed a steady decline in the size of the coefficients after the first lag of the dependent variable, suggesting an auto-regressive order 1 (AR(1)) process. The partial correlogram revealed a strong partial correlation between $PD_t$ and $PD_{t-1}$ but very small partial correlations for $PD_t$ and $PD_{t-k}$ for $k>1$. This further indicated an AR(1) process. Next, we estimate the AR(1) model using OLS:

$$PD_t = \beta_k PD_{t-k} + \varepsilon_t$$

We performed some diagnostic tests of the residuals of the regression. Specifically, we tested for autoregressive conditional heteroskedasticity (ARCH) using a Lagrange Multiplier test. ARCH residuals have the characteristic that high values of the estimated residuals bunch together temporally. ARCH residuals are quite common in time series analysis of economic variables. The Lagrange Multiplier test allows us to reject at the 1-percent level the null hypothesis that the residuals are *not* ARCH.

We re-estimate the model using the maximum likelihood method and including a GARCH(1,1) component to correct for the ARCH residuals.[10] This is the most standard version of this type of model. The correlogram and partial correlogram of the residuals of the new specification reveal no further ARCH terms.[11]

Finally, we estimate the model over the entire time period, including the dummy variable for exports. The model was estimated using the entire sample and adding an indicator variable for dates after the export ban was

[9] We used the period before the ban was lifted to test for stationarity because if we had included the lifting of the ban and the period following that event, then the differential might change as a result of lifting the ban. This, in turn, could cause us to incorrectly conclude that the time series is nonstationary.

[10]The GARCH(1,1) estimation includes an auto-regressive term and a moving-average term to correct for the existence of ARCH residuals. The price differential and variance equations are estimated simultaneously.

lifted. (We used May 28, 1996.) The equation is estimated using maximum likelihood methods and including a GARCH(1,1) component to correct for ARCH residuals. The final price differential model is

$$PD_t = \alpha + \beta PD_{t-1} + \gamma\delta_t + \varepsilon_t \ .$$

[11]To further ensure that the price differential model did not have a unit root or was otherwise misspecified, we performed a test for model specification developed by Davidson, Godfrey, and MacKinnon (1985). This is equivalent to the Plosser-Schwert-White (1982) differencing test. The test statistics for the Davidson, Godfrey, and MacKinnon test do not allow us to reject the null hypothesis that the differenced and undifferenced models result in identical parameter estimates. This is strong evidence that our original model is properly specified.

# GAO Contacts and Staff Acknowledgments

## GAO Contacts

Daniel Haas (202) 512-9828

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