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Implications Of Lifting The Ban On The Export Of Alaskan Crude Oil: Price and Trade Impacts

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ENERGY INFORMATION ADMINISTRATION
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PREFACE

The Energy Issues group of the United States General Accounting Office requested that the Energy Information Administration (EIA) analyze the implications of lifting the ban on the export of Alaskan crude oil. This is EIA's second response to that request. The main objective of both reports is to estimate the potential impacts on crude oil and product prices as well as on petroleum trade flows. The quantitative results in the present report supersede those in the first since they are based on a more comprehensive modeling system. The first report addressed 1988 only and assessed the potential effects of lifting the ban on Alaskan exports on a region by region basis, but without the secondary effects of changes in one region on the situation in another region. The second report looks at both 1988 and 1995 and explicitly models the changes in trade flows that cause those secondary effects.

CONTENTS

Tables

Page

Figures

Page

EXECUTIVE SUMMARY

This study addresses the issue of the ban on exports of Alaskan crude oil. At present almost all crude oil production from Alaska must be sold in the United States, i.e., it may not be exported. This study examines the impact, mainly on the West Coast, of eliminating this export restraint. The study concentrates on two time periods. These are 1988, the most recent year for which complete data are available, and 1995, a year in which Alaskan production is projected to be substantially less than at present.

This is the Energy Information Administration's (EIA's) second report on this subject. The first was released earlier in 1990. They differ principally in the years for which results are presented and in the models used to generate quantitative results. The first report was limited to 1988. The quantitative results for that year were based on use of a single region model and therefore did not take into account petroleum interactions among all areas of the world. Because of this limitation, quantitative results were limited to Alaskan crude oil prices. All other price and trade flow results were qualitative. In contrast, the present report covers both 1988 and 1995. The quantitative results are generated with use of a more comprehensive model, one which does take into account petroleum interactions among all areas of the world. The model-generated results cover both crude and product prices as well as petroleum trade flows. The quantitative results in the present report therefore supersede those in the first, although both sets are generally consistent.

The major conclusions of this analysis are:

- In both 1988 and 1995, substantial volumes of Alaskan oil would be exported if the ban were lifted, because the refinery yield pattern (i.e., percent gasoline, distillate, etc.) from Alaskan oil is better suited for Far East markets than for the West Coast. More Alaskan oil would have been exported in 1988 than in 1995 because Alaskan production was much higher in the earlier year than it is expected to be in the latter year.

- If exports were allowed, then the price of Alaskan oil would increase due to its greater economic value in Far East markets. In both 1988 and 1995, this price increase could amount to about $0.25 per barrel if exports were restricted to 400 thousand barrels per day. In 1988 this price increase might have been in excess of $2.00 per barrel if exports had been completely unrestrained, a highly unlikely situation because of institutional relationships.

- Although crude oil prices could increase, it is unlikely that petroleum product prices would show much of an increase because these products are traded in a competitive market and because higher crude oil costs could be offset by lower processing costs.

- If the export ban were eliminated, it is likely that Alaskan oil would be exported to Japan and other Asian markets and that this oil would be replaced by imports from Latin America, the Middle East (especially from the United Arab Emirates and Qatar) and Malaysia.

It is difficult to establish the exact volumes of Alaskan crude oil that would be exported. At a minimum, the more than 300 thousand barrels per day of oil that was delivered to the U.S. Gulf and East Coasts would have been exported. At the high end, much greater volumes, even in excess of the 500 thousand barrels per day not used on the West Coast, could have been exported due to the superior characteristics of Alaskan oil wit regard to Far East market product demand. Long-standing institutional arrangements could potentially limit the volumes imported by Far East markets.

The following tabulation shows the yield pattern (oil assay) of Alaskan oil compared to the demand slate for the Far East and West Coast markets.

Yield and Demand Patterns

	Percent Gasoline	Percent Distillate
Alaskan Oil Yield	8	30
Far East Demand	13	26
West Coast Demand	46	16

It is clear from these data that Alaskan oil is better suited to the demand pattern of the Far East than to that of the West Coast, which has a very high demand for gasoline. It is this characteristic that drives the results of this analysis.

Because of the export ban, Alaskan oil now sells at a depressed price on the West Coast. Currently, the price of Alaskan oil is determined by market forces on the Gulf Coast. However, by 1995, Alaskan oil should sell at near market prices even on the West Coast because much smaller volumes are expected to be produced.

If the ban were lifted, Alaskan oil could sell in markets where its highest value would be realized. The amount of the price increase would likely be determined by the volume of oil actually exported, as shown below.

Increase in the Price of Alaskan Oil
(Constant 1988 Dollars per Barrel)

Maximum Allowable Volume of Exports	1988	1995
200 MB/d	$0.15	$0.13
400 MB/d	0.25	0.19
800 MB/d	0.94	0.19
Unrestricted Exports	2.16	0.19

These estimates show that in both 1988 and 1995 the price increase would be similar for similar export volumes, with the major difference being in the unrestricted case. In 1988 it is estimated that a much higher volume of Alaskan exports could have been justified on economic grounds than in 1995 because production is projected to decline dramatically by 1995. Alaskan oil production is projected to fall from 2.0 million barrels per day in 1988 to 1.3 million barrels per day in 1995.

Even though crude oil prices could be expected to change as a result of lifting the ban on Alaskan exports, petroleum product prices are not expected to show a significant change (about 1 cent per gallon). This expectation is based on the fact that petroleum products are already traded on the world market and therefore are linked to world oil prices. In addition, if Alaskan oil were replaced by higher-cost crudes on the West Coast, these crudes would require less processing and therefore cost less to produce the needed volume of gasoline. Residual fuel prices are not expected to change much because residual fuel demand formerly satisfied by West Coast supply may be supplied by sources in the international market.

World oil trade patterns would be affected by the elimination of the export ban. It is estimated that most of the exports of Alaskan oil would go to Japan and other Asian markets while this oil would be replaced by imports from Latin America (mainly Mexico and Ecuador), the Middle East (such as the United Arab Emirates and Qatar), and Malaysia. Since the West Coast would be importing crude oils better suited for gasoline production than Alaskan oil, gasoline imports could have declined by between 50 to 100 thousand barrels per day in 1988 and by about 65 thousand barrels per day in 1995. However, product exports would also decline, leaving net product imports largely unchanged in both years.

1. INTRODUCTION

Present legislation effectively bans the export of crude oil produced in the United States. The ban has been in effect for years and is particularly stringent with respect to crude oil produced in Alaska, particularly on the North Slope. The Alaska crude export ban is specifically provided for in the Trans-Alaska Pipeline Authorization Act of 1973 and in other legislation. It was imposed for two reasons. The first was to reduce U.S. dependence on imported crude oil. The Arab oil embargo had been imposed shortly before the Act was passed and a greater measure of energy independence was considered imperative at that time. The second reason was to assure that funds expended in building an Alaskan pipeline would benefit domestic users rather than being simply employed to facilitate shipments to other countries.

The ban on exports of domestically produced crude oil is not total. Exceptions are permitted, but the conditions that must be met are stringent. Currently, only small quantities are exported. In 1988, for example, shipments from the United States and its territories amounted to only 13 thousand barrels per day and were destined only for Canada and China/Taiwan. Exports to the China/Taiwan area were from Alaska's Cook Inlet. Licenses to export crude oil from parts of Alaska's Cook Inlet have been issued since 1986.

The main objective of this report is to estimate the potential impacts on crude petroleum and petroleum product markets that would result from lifting the export ban on Alaskan crude oil.[1] The report focuses on Asian markets and

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[1]This is the second of two reports on this subject. The first was entitled Implications of Lifting the Ban on the Export of Alaskan Crude Oil, SR/EMEU/90-1 (Washington, DC, March 1990). The Energy Information Administration's (EIA's) Refinery Yield Model (RYM) was used to generate results for the first report. The RYM results were restricted to Alaskan North Slope (ANS) crude oil prices since that model is a single region model. The present report is based on results generated by a different EIA model, one which takes into account petroleum interactions among all areas of the world. Prices and shipment volumes are generated for both crude oil and petroleum products for each of the world's refining regions. The emphasis is on Alaska, the West Coast, and Japan since those are the areas that would be principally affected by the elimination of the ban on the export of Alaskan crude oil. The model-generated results in the present report supersede those in the first even though both sets of results are generally consistent.

the U.S. West Coast market, and on the export volume and price of Alaskan crude.[2]

Section 2 describes the factors that would determine the trade flow of Alaskan crude oil if the export ban were abolished. These flows are determined by the demand for petroleum products in domestic and foreign markets, since the demand for crude oil is a derived demand. The ability of Alaskan crude oil to satisfy end-use demand, however, depends on the crude oil assay of that oil and the refinery configurations in various regions, particularly on the U.S. West Coast and in Japan.

Section 3 describes the methodology used to generate the results presented in this report, including the values for Alaskan crude oil. The Energy Information Administration's (EIA's) Transportation and Refining of International Petroleum (TRIP) model was used to generate these values. TRIP is a linear programming model whose objective function is to minimize the sum of all global resource costs. The model simulates the worldwide refining environment, including Japan and the U.S. West Coast, and takes as given the 1988 and 1995 values for product demand slates and refinery configurations in those areas and the characteristics of Alaskan North Slope (ANS) and other crude oils.

Section 4 presents and analyzes the model-generated results and related data. The elimination of the export ban on Alaskan crude oil would likely cause substantial volumes of that crude to be exported and its price to rise. The reason is that Alaskan crude oil is better suited to produce the middle distillate types of products required in the Pacific Basin than it is to produce the gasoline that is in heavy demand on the West Coast. The effects would have been greater if the ban had been eliminated in 1988 than they would be if it were eliminated in 1995. (The ban is assumed to be eliminated at the start of the year.) By the latter year, the continued decline in ANS crude oil production would cause the price of that crude to approach free-market prices even with the ban in effect. Exports of ANS crude oil could have ranged from 500 thousand barrels per day to 1.5 million barrels per day and prices of that crude could have increased by $0.50 per barrel to over $2.00 per barrel in 1988 if the ban had been eliminated in that year. In contrast, ANS crude exports would not likely increase by more than 400 thousand barrels per day and prices of that crude by not more than $0.20 per barrel if the ban were eliminated in 1995. The exports would likely be directed to the Pacific Basin. Compensating volumes of crude would be imported.

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[2]The term "West Coast," as used in this report, refers to Petroleum Administration for Defense District V (PADD V). PADD V consists of Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

Product prices on the West Coast would not be greatly affected by the elimination of the ban. Trade in products is not subject to volume constraints and price changes are effectively limited by international prices and transport costs. Product prices on the West Coast, including the prices of gasoline, could have increased by about 1 cent per gallon in 1988 and could even decrease by as much as 1 cent per gallon in 1995. The volume of gasoline imported into that area would decrease as refineries on the West Coast produce more gasoline with more suitable crudes. Exports of residual fuel oil from the West Coast would also decline as production of that product by refineries in that area decreases.

Section 5 discusses the limitations and qualifications of the analysis. They relate principally to the model, the assumptions made, and the results generated. The principal limitation of the model is that all effects from eliminating the ban are instantaneously reflected in a new equilibrium solution. In reality, effects require time to be realized in the marketplace. Therefore, the effects generated by the model for years in which the ban is assumed to be eliminated may be overstated. The model also assumes that refinery capacity throughout the world is the same in 1995 as in 1988. This could affect processing costs, crude and product prices, and volumes traded. This limitation reflects the absence of adequate information on future changes in refinery configurations. Another limitation relates to world crude oil production, including ANS production. Oil production is assumed to not vary when the ban is eliminated even though in reality ANS production could increase to some extent with higher prices. The effects of changing the assumed level of ANS production as well as modifying certain other assumptions is discussed. The results generated by the model should be viewed in terms of general orders of magnitude which could be roughly approximated over time if there were no offsetting factors rather than looked upon as highly accurate point estimates.

2. FACTORS AFFECTING THE TRADE FLOW OF ALASKAN CRUDE OIL

Crude oils differ. Both the sulfur content and American Petroleum Institute (API) gravity of a specific type of crude oil partially determine its value. In addition, the first cut of one type of crude oil (crude oil assay) from a crude oil distillation unit affects its value; crude oils which produce intermediate products that require less processing to match end-use demand generally command higher prices.

To determine the demand for Alaskan oil outside the United States requires that potential markets which value Alaskan oil more highly than the price of that oil on the U.S. West Coast be identified. That is, if the ban on the export of Alaskan crude were lifted, Alaskan crude would flow to foreign refining regions only if the offering prices for that crude in those regions were higher than on the U.S. West Coast.

Major factors that determine both domestic and foreign demand for Alaskan oil are as follows:

- Demand for refined products
- Refinery configurations
- Crude oil mixes used in refineries
- Characteristics of Alaskan North Slope crude oil
- Transportation costs

Potential markets for Alaskan crude oil are in the Pacific Basin because of its proximity to Alaska and the compatibility of refinery configurations and demand slates in that area with Alaskan crude oil. For this reason, this analysis focuses on five major refining regions: the U.S. West Coast, Japan, Southeast Asia (limited to Brunei, Malaysia, Singapore, and Taiwan), Other Asia and Australia and New Zealand.

Demand for Refined Products

The demand for refined products in any region is determined by many factors. These include climate, geography, the socio-economic structure of the region and its stage of economic development. Principally for these reasons, the composition of demand for refined products in Japan, Southeast Asia, and Other Asia differs sharply from that on the West Coast (Table 1 and Figure 1). In 1988, for example, the gasoline share in the refined petroleum product market was less than 16 percent in Japan, less than 14 percent in Southeast Asia, and less than 10 percent in Other Asia, but exceeded 45 percent on the West Coast.

Table 1. Demand for Refined Petroleum Products in Five Regions in 1988
(Demand in Thousands of Barrels per day; shares in percent)

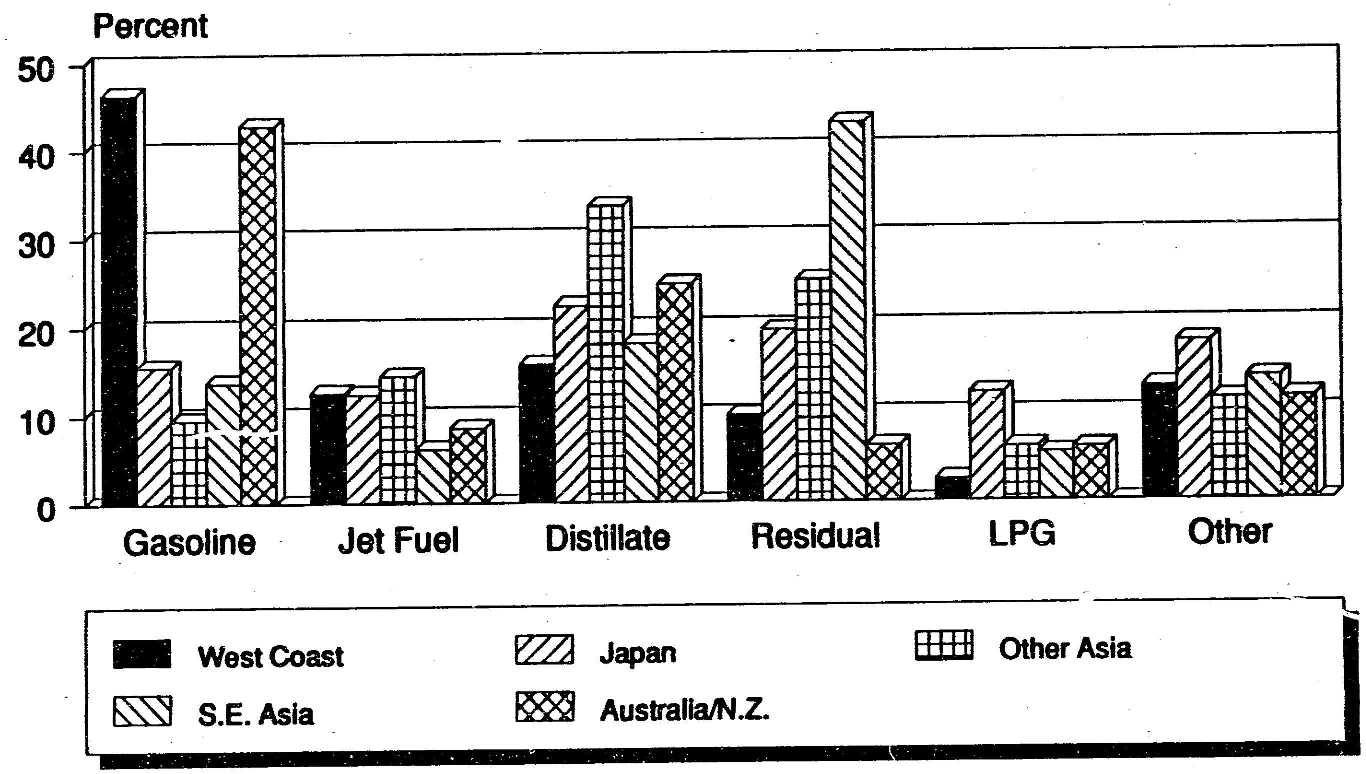
	West Coast		Japan		Southeast Asia		Other Asia		Australia/NZ	
	Demand	Market Share	Demand	Market Share	Demand	Market Share	Demand	Market Share	Demand	Market Share
Motor Gasoline	1,251	46.4	677	15.5	131	13.7	278	9.5	328	42.8
Jet Fuel	341	12.6	541	12.4	58	6.1	424	14.4	65	8.5
Distillate Fuel	423	15.7	970	22.3	171	18.0	985	33.5	188	24.6
Residual Fuel	268	9.9	851	19.5	407	42.9	734	25.0	48	6.3
Liquified Petroleum Gases	68	2.5	536	12.3	51	5.4	179	6.1	46	6.0
Other	348	12.9	783	18.0	132	13.9	339	11.5	90	11.7
Total	2,699	100.0	4,358	100.0	950	100.0	2,939	100.0	766	100.0

Note: Sum of components may not equal total due to independent rounding.
Sources: Energy Information Administration, Petroleum Supply Annual 1988, DOE/EIA-0340 (88/1) (Washington, DC, May 1989) and Organization for Economic Cooperation and Development, Quarterly Oil and Gas Statistics, selected issues. Estimates for non-OECD countries are based on 1987 demand patterns and estimated 1988 total demand.

The market share of residual fuel oil was about 20 percent in Japan, 25 percent in Other Asia, and 43 percent in Southeast Asia, but less than 10 percent on the West Coast. The market share of distillate fuel on the West Coast was the smallest among all five regions.

The significant differences in the demand for refined petroleum products indicate that the demand for Alaskan oil may be very different in these five regions. New developments in the world petroleum market could contribute further to these differences. For example, increased concern over environmental issues has led to tightened specifications for refined products and to the use of lower sulfur crude oil, such as Alaskan oil. On the other hand, increased demand for gasoline tends to have a negative effect on the demand for Alaskan crude oil due to its low yield in the gasoline range of products. However, the current market share for gasoline is relatively small in Japan, Southeast Asia, and Other Asia, compared with the West Coast. Therefore, a slightly higher demand for gasoline in the future may not reduce the competitiveness of Alaskan oil in these regions.

Figure 1. Comparison of Demand Shares of Refined Products in Five Regions in 1988



Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).

Sources: Energy Information Administration (EIA), *Petroleum Supply Annual 1988*, DOE//EIA-0340 (88/1) (Washington, D.C., May 1989); Organization for Economic Cooperation and Development (OECD), *Quarterly Oil and Gas Statistics*, selected issues; estimates for non-OECD countries based on 1987 historical demand patterns and estimated 1988 total demand.

Refinery Configurations

Table 2 and Figures 2, 3, and 4 compare capacities for key refinery processing units on the West Coast and in Japan, Southeast Asia, Other Asia, and Australia/New Zealand in 1988. The capacities for these processing units reflect the effect of crude oil mixes that are most likely to be used in each region, the demand for refined products, and the configuration of the refineries in meeting indigenous or export demand for refined products. In general, crude oil distillation capacities are closely correlated to the total demand for refined products in each region.

Table 2. Capacities for Key Refinery Processing Units in Five Major Regions in 1988
(Thousand Barrels per Day)

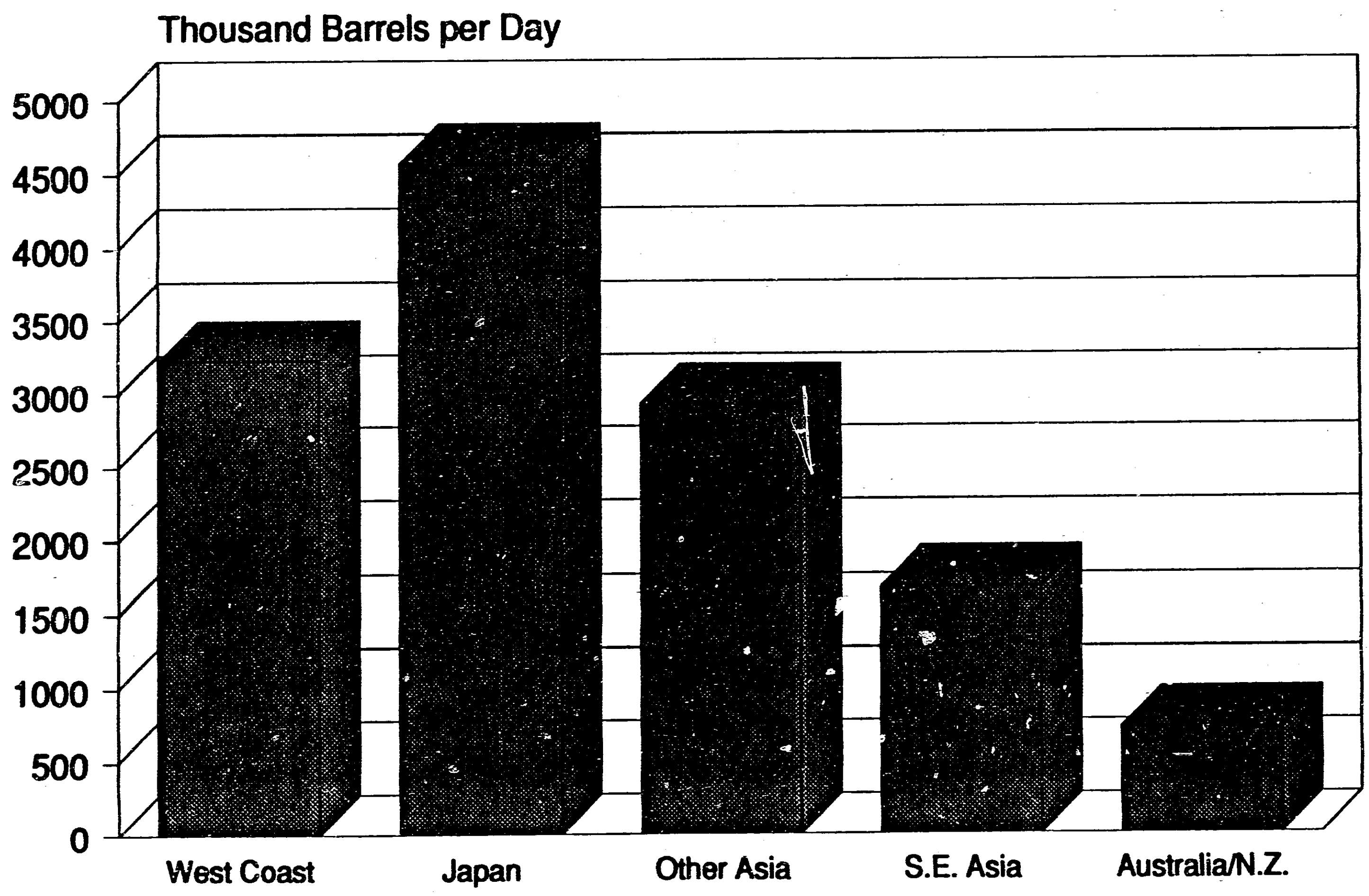
Processing Units	West Coast	Japan	Southeast Asia	Other Asia	Australia/ N.Z.
Crude Distillation	3,231	4,567	1,680	2,927	719
Vacuum Distillation	1,649	1,676	387	591	218
Coker-Delayed	412	23	0	26	0
Coker-Fluid	110	0	0	0	0
Viscbreaker	64	60	153	211	0
Naphtha Hydrotreater	573	850	219	275	105
Distillate HDS	373	1,377	165	193	192
FCC Feed Hydrofiner	490	208	137	115	11
Resid Desulfurizer	235	1,043	103	51	17
CAT Reformer High Pressure	384	476	124	137	157
CAT Reformer Low Pressure	322	58	14	71	2
Fluid CAT Cracker	773	557	25	197	185
Hydrocracker	465	51	68	11	20
Alkylation Plant	146	11	4	4	33

Sources: Energy Information Administration, Petroleum Supply Annual 1988, DOE/EIA-0340(88/1) (Washington, DC, May 1989), and Oil and Gas Journal, December 28, 1987.

Two major categories of processing units stand out in the comparison. The first cracks the heavy end of a barrel to lighter products and the second removes sulfur from the products.

Cracking capacities were substantially greater on the West Coast than in the other four regions in 1988. On the West Coast, capacities for Cokers, Hydrocrackers, and Fluid Catalytic Crackers were 522 thousand barrels per day,

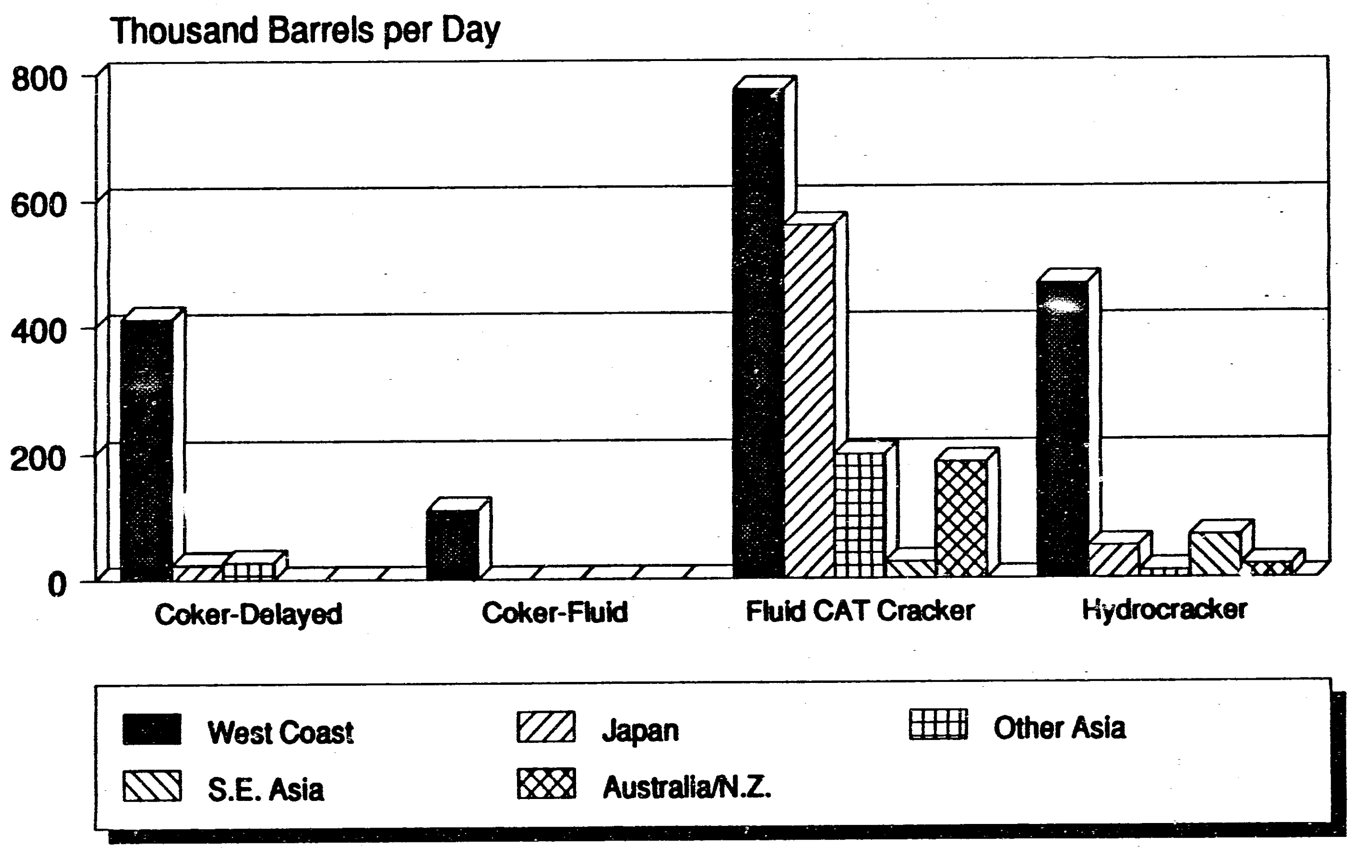
Figure 2. Comparison of Distillation Capacities in Five Regions in 1988



Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).

Source: Energy Information Administration (EIA), *Petroleum Supply Annual 1988*, DOE/EIA-0340 (88/1) (Washington, D.C., May 1989) and *Oil and Gas Journal*, December 27, 1987.

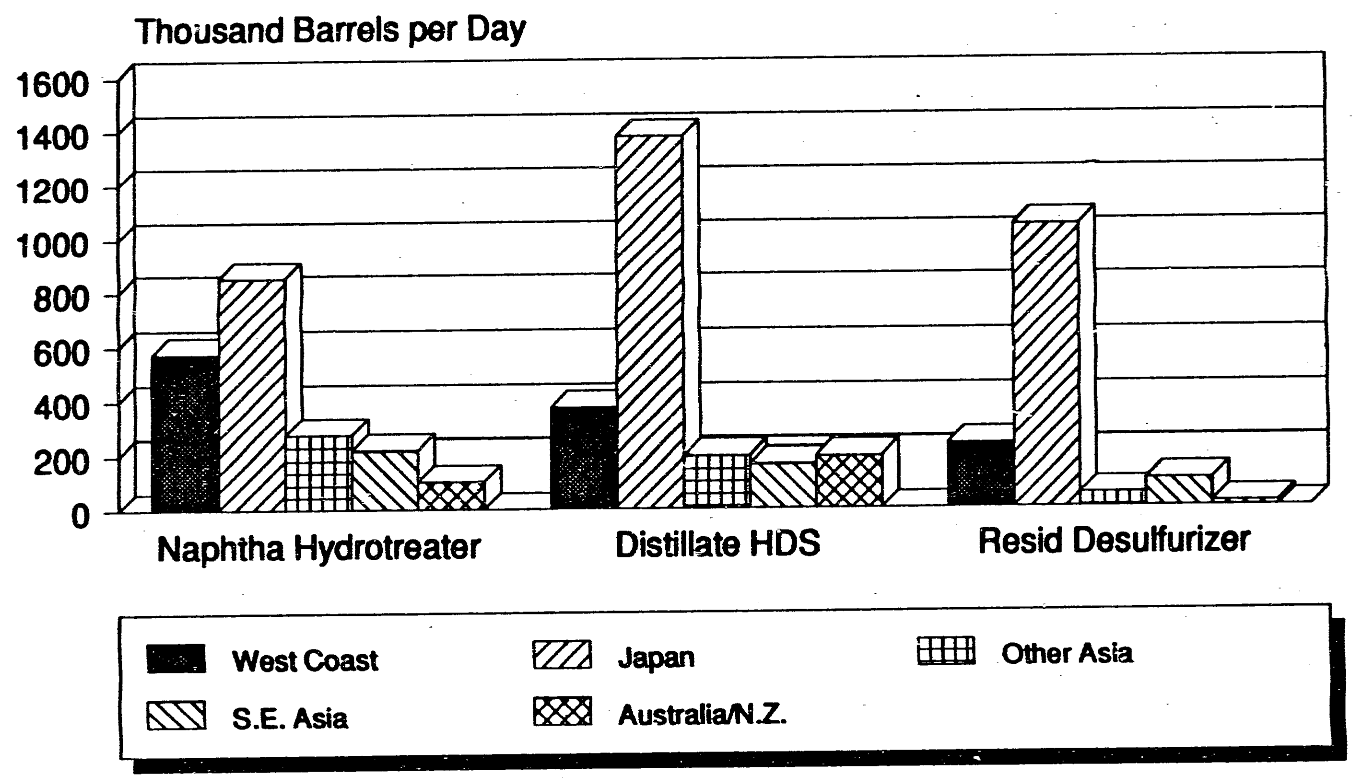
Figure 3. Comparison of Cracking Capacities in Five Regions in 1988



Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).

Source: Energy Information Administration (EIA), *Petroleum Supply Annual 1988*, DOE/EIA-0340 (88/1) (Washington, D.C., May 1989) and *Oil and Gas Journal*, December 27, 1987.

Figure 4. Comparison of Major Hydrotreating Capacities in Five Regions in 1988



Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).

Source: Energy Information Administration (EIA), *Petroleum Supply Annual 1988*, DOE/EIA-0340 (88/1) (Washington, D.C., May 1989) and *Oil and Gas Journal*, December 27, 1987.

465 thousand barrels per day, and 773 thousand barrels per day, respectively, in 1988. A Coker converts asphalt or residual fuel oil to intermediate products to be processed in either a Fluid Catalytic Cracker or a Hydrocracker. A Hydrocracker converts higher boiling point petroleum materials such as aromatic cycle oils and coker distillates into gasoline and jet fuels. A Fluid Catalytic Cracker converts heavy oils into gasoline and lighter products. The greater cracking capacity for these conversion units on the West Coast than in Japan and other Pacific Rim countries reflects the effect of much greater market demand for gasoline and much heavier crude oil mixes on the West Coast with respect to the requirement to convert the heavy-end of a barrel into lighter products.

In contrast, hydrotreating units in Japan have a much greater capacity than those on the West Coast and other Pacific Rim refining regions. In Japan, capacities for Naphtha Hydrotreaters, Distillate Hydro-Desulfurizers, and Residual Fuel Desulfurizers were 850 thousand barrels per day, 1,377 thousand barrels per day, and 1,043 thousand barrels per day, respectively in 1988.

The differences in the capacities of desulfurization units between the West Coast and Japan reflect the greater Japanese demand for naphtha, distillate fuel oil, and residual fuel oil, and environmental restrictions on the sulfur content of these fuels.

Crude Oil Mixes Used in Refineries

Given the demand for end-use petroleum products and refinery configurations, the output of refined products and the efficiency of refinery operations depend largely on the quality and volume of crude streams available to a refinery. The optimal crude oil mix would include crude oils with sulfur content, API gravity and crude oil assay that are best suited for processing in a given refinery and that minimize the cost of meeting a particular mix of petroleum demand.

In 1988, the four foreign refining regions processed the types of crude oils shown in Table 3. In general, the API gravity of these crudes are higher than 27°, and the sulfur content of most of them are greater than 1.5 percent by weight, except crude oils from Algeria, China, Ecuador, Indonesia, Malaysia, Nigeria, and Norway. On average, these foreign crude oils are better gasoline producers than those indigenous crudes used on the West Coast. However, the capability of these lighter oils to produce lighter products such as gasoline is not fully utilized in regions such as Japan, Southeast Asia and Other Asia due to the relatively low demand for gasoline and the much higher demand for distillate fuel and residual fuel in those areas.

The West Coast imported about 200 thousand barrels of crude oil per day in 1988. The remaining crude oil used in that area was indigenous West Coast production, which included about 1.4 million barrels per day of crude from Alaska. The average API gravity of the crude used by the West Coast refineries was lower (heavier) than for those used in the four foreign refining regions.

Table 3. Types of Crude Oil Used in Four Foreign Regional Refineries in 1988

	Japan	Southeast Asia	Other Asia	Australia/ N.Z.
Algeria		X	X	
Australia	X	X	X	X
Canada	X	X	X	X
China	X	X	X	
Ecuador			X	
Egypt	X	X	X	
Indonesia	X	X	X	X
Iran Heavy	X	X	X	X
Iran Light	X	X	X	X
Iraq	X	X	X	
Kuwait	X			X
Malaysia	X	X	X	X
Mexico	X	X	X	
Nigeria		X	X	
Norway		X	X	
Saudi Heavy	X	X	X	X
Saudi Light	X	X	X	X
USSR	X	X	X	
U.A.E./Qatar	X	X	X	X
Venezuela	X	X		
Other Africa		X	X	

Source: Energy Information Administration, International Energy Annual 1988, DOE/EIA-0219(88) (Washington, DC, November 1989), and International Energy Agency, data tape of Quarterly Oil Statistics, third quarter 1989.

In a competitive oil market, a profit maximizing refiner would be continuously seeking that crude oil mix which minimizes operating costs and maximizes profits. In general, the optimal crude oil mix to a refinery changes as the available crude oil and demand slate for refinery products change.

Characteristics of Alaskan North Slope Crude Oil

Alaskan North Slope (ANS) crude oil has an API gravity of 26.4°, and a sulfur content of 1.06 percent by weight. The assay of ANS crude indicates that it produces a very small fraction of gasoline range products (isobutane, light straight-run gasoline, and light naphtha as gasoline blending components). The sum of these fractions is less than 8 percent (Table 4). In a market like the West Coast, which has very high gasoline demand, a great deal more

Table 4. Alaskan North Slope Crude Oil Assay

Intermediate Products	Crude Fraction
Gas	0.004
Propane	0.002
Isobutane	0.005
N. Butane	
Light Straight Run, LON (C5-175)	
Light Straight Run, ION (C5-175)	0.021
Light Straight Run, HON (C5-175)	0.013
Light Naphtha Paraffinic (175-250)	
Light Naphtha Intermediate (175-250)	0.038
Light Naphtha Naphthenic (175-250)	0.002
Naph P (250-325)	
Naph I (250-325)	0.050
Naph N (250-325)	0.006
Heavy Naph P (325-375)	
Heavy Naph I (325-375)	0.020
Heavy Naph N (325-375)	
Kero L. Flash P., LS/LM (375-500)	0.051
Kero H. Flash P., LS/LM (375-500)	0.099
Kero L. Flash P., HS/LM (375-500)	
Kero H. Flash P., LS/LM (375-500)	
Distillate LS/LM (500-620)	0.057
Distillate MS/LM (500-620)	0.072
Distillate HS/LM (500-620)	
Light Gas Oil, N. LS (620-800)	0.045
Light Gas Oil, N. MS (620-800)	0.130
Light Gas Oil, N. HS (620-800)	
Light Gas Oil, P. LS (620-800)	
Heavy Gas Oil N, LS (800-BTMS)	0.030
Heavy Gas Oil N, MS (800-BTMS)	0.155
Heavy Gas Oil N, HS (800-BTMS)	
Heavy Gas Oil P, LS (800-BTMS)	
Resid. Low Sulfur (.2)	
Resid. High Sulfur (2.1)	0.150
Resid. Very High Sulfur (3.2)	0.050
Asphalt Very High Sulfur (4.3)	
Total	1.000

Source: Energy Information Administration, Refinery Evaluation Modeling System (REMS) Model Documentation, DOE/EIA-0460 (Washington, DC, October 1984).

processing is required to convert light gas oil, heavy gas oil, and residual fuel to lighter products such as gasoline and jet fuel. The Fluid Catalytic Crackers and Hydrocrackers would be used to convert gas oils to gasoline and jet fuel, and the Coker process would be used to convert residual fuel to lighter products. The additional processing adds to the cost of producing the lighter products on the West Coast.

In Japan, Southeast Asia, and Other Asia, the demand for distillate fuel and residual fuel is much greater than the demand for gasoline. Therefore, the processing required to convert a barrel of ANS crude to meet the demand slate in those areas would be much less than on the West Coast. In addition, the low sulfur content of ANS crude oil implies a lower utilization of desulfurization units, which would further reduce the cost of processing ANS crude in these foreign regions relative to the West Coast.

Transportation Costs

In a competitive market environment, differences in the prices of Alaskan crude oil in various regional markets cannot exceed differences in the costs of transporting the crude oil. Tanker rates, therefore, play a very important role in determining the movement of Alaskan crude oil at the margin. In general, regions which experience higher transportation costs must value the Alaskan oil more highly, otherwise regions with lower transportation costs will simply receive more oil until the market for Alaskan oil reaches a new equilibrium.

Tanker rates for Alaskan oil from Valdez to various potential foreign refining regions show that Japan has the lowest rate for both the large and very large crude carriers and that the rate to Singapore only slightly exceeds the rate to Los Angeles for large crude carriers (Table 5 and Figure 5).

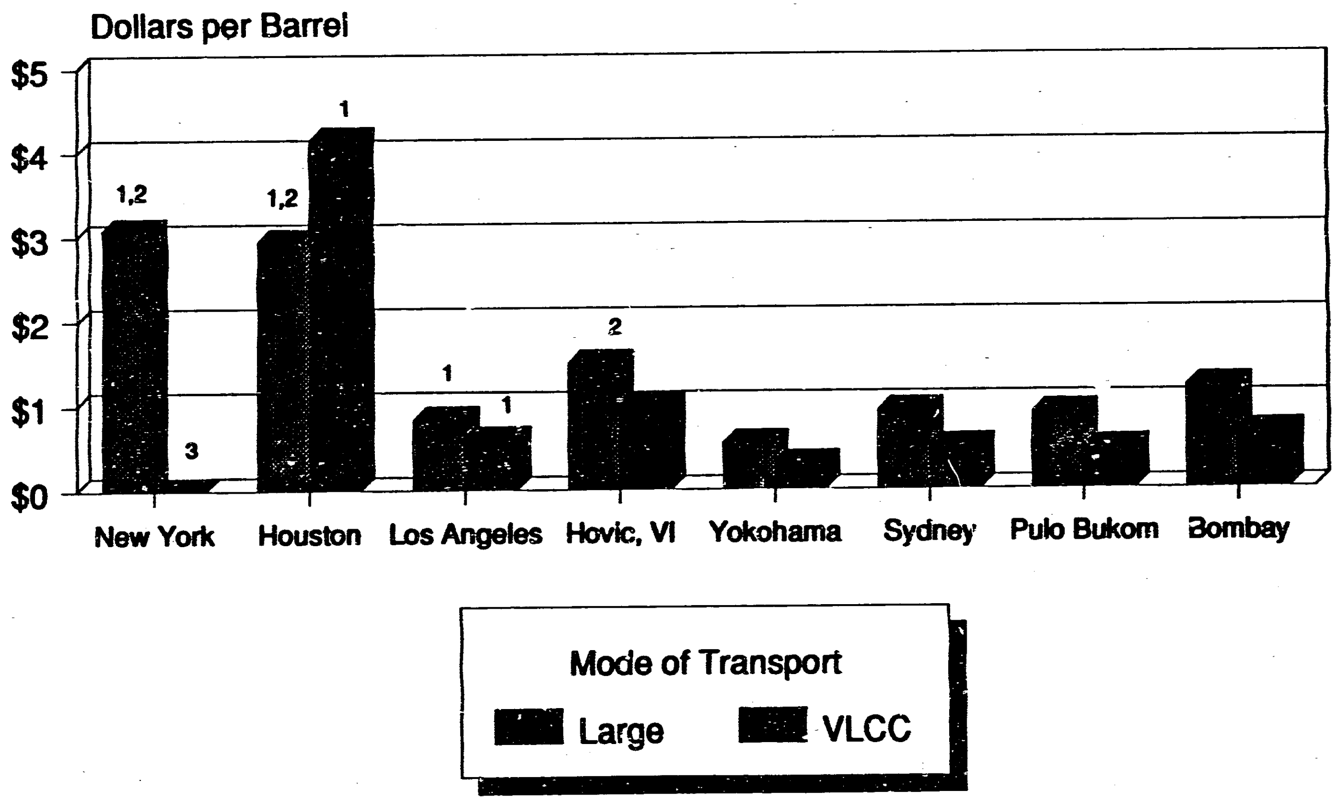
Would refineries in Japan, Southeast Asia, and other Asian countries compete effectively with refineries on the West Coast for at least some portion of Alaskan crude oil? The answer depends on the savings in processing costs that could be achieved by substituting Alaskan crude oil for other imported crudes as well as on the relative prices of Alaskan and internationally traded crudes and their transportation costs. The presumption is that Japanese refineries would be one of the strongest competitors for Alaskan crude, since the cost of transporting the crude to Japan is the lowest and the compatibility of that crude with the Japanese demand slate and refinery configuration is high. The TRIP model described in the next section that takes into account the interactions among all of these factors on a worldwide basis is used in order to reach a firm conclusion.

Table 5. Tanker Rates for Alaskan Crude Oil from Valdez to Various Ports by Type of Carrier in 1988
(Dollars per Barrel)

Destination	Large	VLCC
New York	3.079[a,b]	[c]
Houston	2.938[a,b]	4.147
Los Angeles	0.833[a]	0.606[a]
Hovic, Virgin Islands	1.503[b]	1.004
Yokohama, Japan	0.552	0.315
Sydney, Australia	0.925	0.507
Pulo Bukom, Singapore	0.894	0.491
Bombay, India	1.210	0.663

[a] Jones Act Tanker Rate.
[b] Uses Panama Canal.
[c] There are no VLCC port facilities in New York.
Note: VLCC = Very Large Crude Carrier.
Source: Platt's Oilgram Price Report, October 31, 1988.

Figure 5. Marine Transportation Rates for Crude Oil from Valdez, Alaska to Selected Destinations in 1988



[1] Jones Act tanker rate.
[2] Uses Panana Canal.
[3] There are no VLCC port facilities in New York.
Notes: Large = 60 - 175 thousand deadweight tons; VLCC = > 175 thousand deadweight tons.
Source: TRIP model solutions

3. METHODOLOGY

The effects of lifting the ban on the export of Alaskan crude oil were investigated using the Energy Information Administration's (EIA's) Transportation and Refining of International Petroleum (TRIP) model. The TRIP model provides a simulation of worldwide petroleum activities including crude oil and natural gas liquids supply, petroleum product demand, marine transportation and pipeline distribution, and refinery operations. A linear programming formulation is used in order to satisfy fixed product demand slates while minimizing the sum of all global resource costs. There are no time dynamics in a TRIP model solution. A single solution represents an average daily operating plan for a specified time period (the calendar years 1988 and 1995 for this study).

Supply

A total of forty-nine worldwide crude oil streams are defined in the TRIP model. Thirteen of these crude oils are domestically produced with the remaining thirty-six being indigenous to foreign regions. Each of these crude oils has a unique assay which reflects its processing capabilities in the worldwide refining environment. Forty-eight of the crude oils are introduced to the TRIP model as production upper bounds. In the case of the 1988 simulations, these production upper bounds reflect the actual production levels achieved in 1988; the production levels in the 1995 simulations are EIA estimates. Saudi Arabian Light acts as the marginal world crude oil supply. It is the only crude oil stream that is priced in the TRIP model, with a Free-On-Board (FOB) price of $14.15 for 1988 and an estimated FOB price of $19.00 (in constant 1988 dollars) for 1995. All other crude oil streams are priced (marginal or "shadow" prices) relative to Saudi Arabian Light and reflect any quality or location differences.

In addition to crude oil supplies, the TRIP model also considers three additional categories of liquid raw materials: natural gas liquids, other liquids (e. g., coal liquids and alcohol), and "unaccounted for" supply. It should be emphasized that all supply categories are introduced into the model as point estimates (with the exception of Saudi Arabian Light), i.e., natural resource supplies for any given year are fixed. There are no iterative procedures in the TRIP model which use supply elasticities to vary production quantities as a function of marginal prices.

Demands

The driving force behind a TRIP model simulation is the fixed slate of refined product demand quantities. Worldwide demands of refined products are disaggregated into ten categories. These categories include: premium unleaded gasoline (90-92 octane), regular unleaded gasoline (80-87 octane), gasoline with octane less than 80, No. 2 Distillate Fuel Oil, No. 4 Distillate Fuel Oil, High Sulfur Residual Fuel Oil, Low Sulfur Residual Fuel Oil, Jet Fuel, Liquefied Petroleum Gases, and Other Petroleum Products (e.g., lubes, waxes, and still gas). In addition to refined product demands, demands for unrefined crude oil are specified. Actual 1988 annual average demands were used for the 1988 TRIP model simulations; the 1995 simulations used EIA estimates. Whereas total worldwide petroleum demand is expected to substantially increase by 1995, it is estimated that the relative shares across refined products will not appreciably change, with only a slight increase in the shares of gasolines and middle distillates accompanied by a slight decrease in the shares of residual fuels and liquefied petroleum gases. The marginal prices of refined products in the TRIP model are a function of crude oil price, availability, and quality; the cost of marine and pipeline movements; and the costs incurred in the refinery environment.

All refined product demands are introduced into the TRIP model as fixed point estimates that must be met. There are no iterative procedures which use demand elasticities to vary regional refined product consumption as a function of marginal prices.

Marine Transportation and Pipeline Distribution

There are six categories of crude oil carriers in the TRIP model that differ by size, vessel operating characteristics, and ownership. Ownership refers to the distinction made between foreign-flag vessels versus Jones Act tankers. Worldwide tanker routes are determined for each origin/destination port pair across all tanker categories. These routes are a function of distance, ability to use canals, and ability to berth at a particular port. A marine transportation rate is associated with each tanker category/route combination and was derived for the TRIP model simulations using the 1988 Worldscale Multiplier for foreign-flag vessels and the 1988 American Rate Multiplier for Jones Act tankers. Added to this derived rate is the cost of bunker fuel, insurance, and part-cargo lightering (where appropriate).

The eight categories of refined product carriers in the TRIP model are represented in much the same way as the crude oil carriers. There is a distinction made between vessels that transport clean versus dirty products. Associated with each tanker category (crude oil and refined product) is an upper bound that specifies the total amount of deadweight tonnage available at a particular point in time. Actual 1988 available deadweight tonnage was used for the 1988 TRIP model simulations; the 1995 simulations used a National Petroleum Council estimate of tanker availability in 1990. Tanker availability was not a binding constraint in either the 1988 or the 1995 simulations. One additional category of marine transportation considered in the TRIP model is river barge traffic.

Worldwide crude oil, clean product, and liquefied petroleum gas pipelines are represented in the TRIP model. The geographical coverage of the pipeline representations include: inter-Petroleum Administration for Defense District (PADD) movements, movements across the United States/Canadian border, inter-country movement in Europe, Persian Gulf movements, the SUMED pipeline, and the Panama pipeline. Associated with each pipeline is a capacity and a cost. Actual 1988 capacities and costs were used for both the 1988 and 1995 TRIP model simulations.

Worldwide Refining

The TRIP model contains thirty-three individual refinery models. The United States is represented by PADD-level formulations, while the rest of the world is represented by either national refinery models (e. g., West Germany and France) or higher levels of aggregation. There are no refinery formulations for the Centrally Planned Economies. A given regional refinery representation is defined as the sum of capacities across all individual processing units within that geographical region. Admittedly, this level of aggregation might tend to overstate a region's refining capability; however, model validation efforts in the past have not shown significant discrepancies when comparing model results with a region's historical refinery output.

Lending additional credibility to this particular set of worldwide refinery models is the fact that they were used extensively in the National Petroleum Council (NPC) study on U.S. Petroleum Refining (October 1986). The NPC, employing a group of industry experts on regional refinery operations, examined with great care the assumptions, methodology, and results of the EIA's refinery modeling capabilities. Having been subjected to this rigorous validation process, the current worldwide refining formulations in the TRIP model are regarded as credible representations of worldwide refining operations.

Twenty-four different types of refinery processes are represented in the TRIP model ranging from straight distillation to the more sophisticated downstream processes found in the more complex (therefore, more flexible) refining environments such as the United States, certain European countries, and Japan. Associated with each refinery process is a capacity upper bound and a cost. The cost includes processing and blending operations as well as the return on investment (capital recovery). Both the 1988 and 1995 TRIP model simulations used 1988 process unit capacity upper bounds and refining costs.

Simulation Methodology

An interesting feature of the TRIP model is its ability to stipulate just how close a given solution should adhere to historic patterns of crude oil and refined product trade. This is done on a percentage basis by declaring that a given exporter of crude oil or refined products must not deviate from its historic export shares by more than a certain percentage. This feature was included in the TRIP model formulation because it was recognized that the straight economics of transportation and refining could not adequately capture the institutional constraints (long-term contracts, diversification of supply sources, trade restraints, etc.) of the world petroleum market.

A 1988 and a 1995 business-as-usual (BAU) simulation were generated for this exercise. Because 1988 refinery runs are known, the 1988 BAU simulation allowed virtually no deviation from actual 1988 crude oil trade patterns. Therefore, the crude oil refinery runs in the United States and the Far East were for all purposes identical to the actual 1988 refinery runs. Refined product trade patterns were not locked in because the locking in of crude runs implicitly determines the availability of refined products for export. Because there is a good deal of uncertainty associated with petroleum trade in 1995, trade shares for both crude oil and refined products were allowed to deviate by up to 20 percent from their 1988 historic shares in the 1995 BAU simulation.

Sensitivity simulations were generated for both 1988 and 1995. The ban on exporting Alaskan crude oil was lifted in 200 thousand barrel per day increments across the sensitivity cases with the final sensitivity case being a totally unrestricted Alaskan export case. In the sensitivity cases, regional refinery runs were upper bounded at their BAU levels. United States refiners were allowed to only give up their runs of Alaskan crude oil but could increase their runs of any other domestic or foreign crude oil. Far Eastern refiners were allowed to import Alaskan crude oil but could only decrease their runs of any other domestic or imported crude oil. Refined product trade was allowed to deviate by up to 20 percent of its BAU import and export levels. There were no restrictions placed on the composition of the refined product imports and exports.

4. ANALYSIS OF RESULTS

Crude oil and petroleum product markets would both be affected if the ANS crude oil export ban were eliminated. The later the year of its elimination, the smaller the effects. The reason is that production of ANS crude oil will likely continue to decline sharply in the near future and its price will likely rise toward free-market levels even with the ban in effect. Product prices on the West Coast will not be greatly affected since they are effectively constrained by unrestricted product trade in international markets and by the reduction in West Coast processing costs resulting from the increased use of imported crudes that are better suited to produce gasoline.

Implications for Crude Oil Prices and Trade

Substantial volumes of Alaskan North Slope (ANS) crude oil would probably be exported and its price would rise if the Alaskan oil export ban were eliminated. The relatively higher value that Pacific Rim refineries place on ANS crude relative to the price of that crude on the West Coast with the ban in effect is the reason for this conclusion. However, the magnitudes of the likely export volumes and price increases depend on the year in which the ban is assumed to be eliminated, since the production of ANS crude is declining rapidly. If the ban had been eliminated in 1988, the effects could have been large. If the ban were eliminated in 1995, export volumes would be substantially smaller and price effects would probably be negligible.

Up to 1.5 million barrels per day, or three-fourths, of Alaska's crude oil production could have been exported in 1988 if the ban had been eliminated in that year, and its price (refinery acquisition cost) on the West Coast could have increased by over $2.00 per barrel. If, on the other hand, the ban were eliminated in 1995, only 400 thousand barrels per day of a sharply lower level of production would likely be exported in that year and the price would increase by only about $0.20 per barrel (in constant 1988 dollars).[3] These increases assume instantaneous adjustment of all markets to the new equilibrium levels. In practice, some time would be required before markets adjust completely. The smaller, market-constrained increases are equivalent to those that would result from a partial lifting of the export ban rather than its complete elimination.

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[3] All prices in this report are in constant (1988) dollars.

Figures 6 and 7 depict the relationship between the volumes of ANS crude oil shipped to West Coast refineries and the refinery acquisition cost of that crude at various constrained and unconstrained levels of ANS exports. The greater the volume of exports, the higher the price. In 1988, for example, the price of ANS crude could have risen by nearly $1.00 per barrel if allowable exports had been constrained to 800 thousand barrels, and by over $2.00 per barrel if the export ban had been fully eliminated.

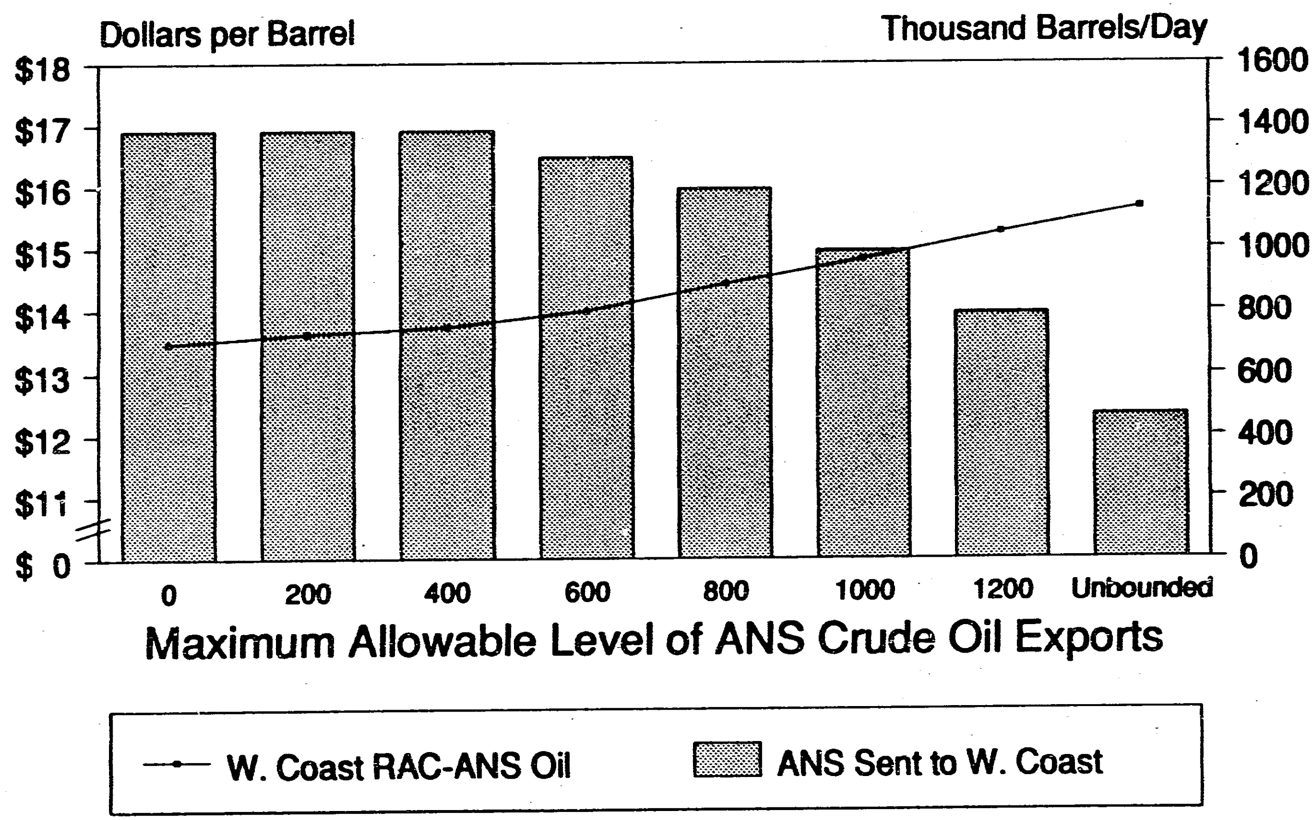
Generally, the volumes of ANS crude shipped to the West Coast decline as the export ban is increasingly relaxed (Table 6). However, at low export levels, shipments to the West Coast would likely have remained essentially unchanged in 1988 since the volumes exported would have been obtained by curtailing shipments to other U.S. markets (Table 7). Shipping ANS crude to those markets is expensive. In 1995, however, there would not likely be any ANS crude shipments to other U.S. markets, because of the lower level of ANS crude production. All exports in that year would therefore result from diverting shipments away from the West Coast. However, exports would not likely exceed 400 thousand barrels per day (and prices would not likely increase by more than $0.20 per barrel) since foreign crudes would be more economical for foreign refiners at the higher prices required to induce additional ANS exports.

Table 6. West Coast Price-Quantity Relationships for ANS Crude Oil at Various Export Levels, 1988 and 1995

Maximum Allowable ANS Exports (MB/d)	ANS Shipments to West Coast (MB/d)	Refinery Acquisition Cost of ANS Crude on West Coast (Constant 1988 Dollars per Barrel)
	1988	
0	1,381	$13.49
200	1,381	13.64
400	1,381	13.74
600	1,291	13.99
800	1,191	14.43
1,000	991	14.82
1,200	791	15.25
1,400	591	15.46
Unbounded	466	15.65
	1995	
0	1,255	20.98
200	1,055	21.11
400	855	21.17
Unbounded	849	21.17

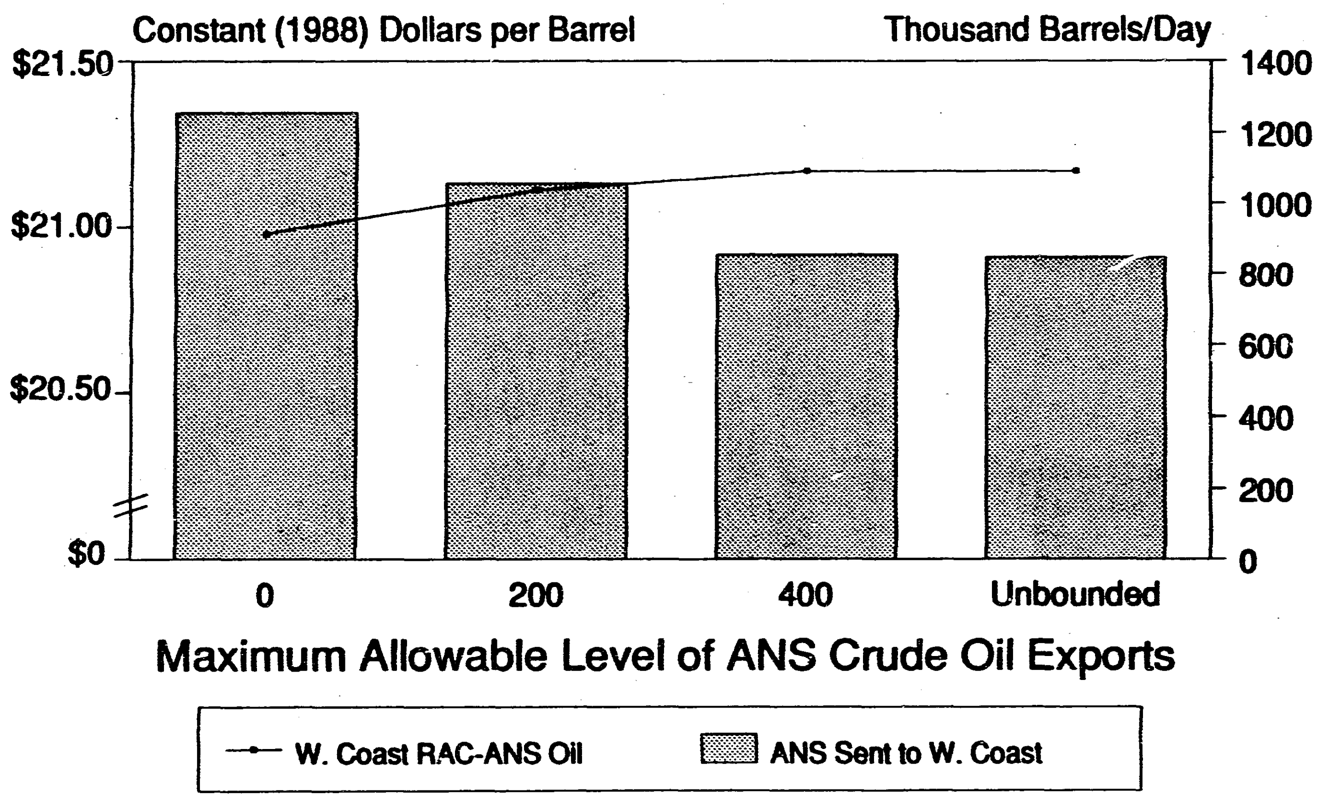
MB/d = Thousand barrels per day.
Source: TRIP model solutions.

Figure 6. West Coast Price-Quantity Relationships for ANS Crude Oil at Various Export Levels in 1988



Notes: RAC indicates refinery acquisition cost; West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: TRIP model solutions.

Figure 7. West Coast Price-Quantity Relationships for ANS Crude Oil at Various Export Levels, Projected 1995



Notes: RAC indicates refinery acquisition cost; West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: TRIP model solutions.

Table 7. Changes in ANS Crude Oil Shipments to Domestic Outlets in 1988 and 1995 Resulting from Constrained and Unconstrained Exports of ANS Crude Oil
(Thousand Barrels per Day)

	Maximum Allowable Level of ANS Crude Oil Exports				
Destination	400 MB/d	800 MB/d	No Ban	400 MB/d	No Ban
		1988		1995	
PADD I	-31	-31	-31	0	0
PADD II	-70	-138	-138	0	0
PADD III	-299	-299	-299	0	0
PADD IV	0	0	0	0	0
PADD V	0	-190	-915	-400	-406
U.S. Territories	0	-142	-142	0	0
Total	-400	-800	-1,524	-400	-406

Notes: o PADD means Petroleum Administration for Defense District. PADD V is the West Coast, which consists of Alaska, Arizona, California, Hawaii, Nevada, Oregon and Washington. o Sum of components may not equal total due to independent rounding.
Source: TRIP model solutions.

The refinery acquisition costs of all other crudes produced on the West Coast, not just ANS crude, could also increase if the Alaskan ban were eliminated. The increases for these other crudes may roughly approximate those for ANS crude at various export levels for both 1988 and 1995 (Table 8).

It is estimated that exports of ANS crude oil could be directed entirely to Japan and other Asian markets if the ban were lifted (Table 9). Alaskan North Slope crude is better suited to the production of middle distillates, for which there is a relatively greater demand in those markets than on the West Coast. The Asian preference for ANS crude is reflected in the higher valuation placed on that crude relative to its value on the West Coast and relative to the value of other crudes with the ban in effect. In 1988, for example, it is estimated that Japan valued ANS crude delivered to its refineries by about \$2.00 per barrel more than the value of that crude on the West Coast and by about \$0.60 per barrel more than for crudes imported from other sources. If the ban had been eliminated in that year, 60 percent of the maximum 1.5 million barrels per day of exported ANS crude could have been shipped to Japan. At a constrained ANS export level of 800 thousand barrels per day, 500 thousand barrels per day could have been sent there. At a constrained export level of 400 thousand barrels per day, about 220 thousand barrels per day could have been directed to that country. If the ban were eliminated in 1995 instead of 1988, three-fourths of the totally unconstrained export level of 400 thousand barrels per day in that year might be shipped to Japan.

Table 8. Increases in West Coast Refinery Acquisition Costs of Crude Oil Produced in that Area at Various Export Levels, 1988 and 1995 (Constant 1988 Dollars per Barrel)

	Maximum Allowable Level of ANS Crude Oil Exports		
Crude Source	400 MB/d	800 MB/d	Unbounded
		1988	
Alaskan North Slope	$0.25	$0.94	$2.16
All Other West Coast	.24	.88	2.00
Total West Coast	.25	.89	1.85
		1995	
Alaskan North Slope	0.19	NA	0.19
All Other West Coast	0.21	NA	0.21
Total West Coast	0.08	NA	0.08

NA = Not applicable.

Note: The increase in the cost for Total West Coast crude is usually less than the increases in the costs of individual West Coast crudes because of changes in the relative volumes of the different types of crude. Specifically, the increase in the cost for Total West Coast crude is the difference in the weighted averages of the individual cost levels rather than the weighted average of differences in those levels. The weights are the volumes of individual crudes produced on the West Coast that were acquired by refineries in the region. The volumes change according to the maximum allowable level of ANS crude oil exports.

Source: TRIP model solutions.

The loss of ANS crude to U.S. refiners through exports would likely be compensated for by an essentially equal increase in the volume of imported crude (Table 9). If the ban had been eliminated in 1988, most of the increase would likely have originated from Latin America (particularly Mexico and Ecuador), the Middle East (especially the United Arab Emirates and Qatar), and Malaysia. If the ban were eliminated in 1995, nearly all of the increase would likely come from the United Arab Emirates and Qatar. Latin American crudes are generally heavier than Middle East crudes and not as well suited to meet U.S. demand for light products. Middle East crudes can more readily accommodate the 1995 increase in U.S. import demand since that increase is only one-fourth as great as the 1988 increase. The increase in imports would have gone to the Gulf and West Coasts and to U.S. territories in 1988 but would likely go only to the West Coast in 1995, since ANS shipments to beyond the West Coast would have been fully backed out prior to 1995.

Table 9. Changes in U.S. Crude Oil Exports and Imports in 1988 and 1995 Resulting from Constrained and Unconstrained Exports of ANS Crude Oil
(Thousand Barrels per Day)

	Maximum Allowable Level of ANS Crude Oil Exports				
Destination/ Source	400 MB/d	800 MB/d	No Ban	400 MB/d	No Ban
	1988			1995	
A. Exports					
Japan	220	501	886	309	315
Australia/N.Z.	0	0	0	0	0
Southeast Asia	0	0	0	0	0
Other Asia	180	299	639	91	91
Other Foreign	0	0	0	0	0
Total	400	800	1,525	400	406
B. Imports					
Ecuador	0	148	162	0	0
Mexico	337	461	377	0	0
Trinidad	0	38	68	0	0
Bolivia/Peru	63	111	149	0	0
Kuwait	0	0	0	-101	-101
UAE/Qatar	0	42	502	515	519
Iraq	0	0	0	-138	-143
Malaysia	0	0	238	99	98
All Other	0	0	29	23	32
Total	400	800	1,525	398	405

Source: TRIP model solutions.

The weighted average West Coast refinery acquisition cost of imported and domestically-produced crudes could increase if the export ban were eliminated. The 1988 increase could have amounted to nearly $0.25 per barrel at the 400 thousand barrel per day ANS export level, less than $1.00 per barrel at the 800 thousand barrel per day level, and nearly $2.00 per barrel at the unconstrained export level (Table 10). It is estimated that prices would not increase substantially in 1995, regardless of the level of exports. Nearly all of the increases in either year originate from increases in the price of domestically-produced crude. The only exception is at the unconstrained level of exports in 1988, where the refinery acquisition cost of imported crude increased by $0.55 per barrel while that for domestic crude increased by nearly $2.00 per barrel.

Table 10. Changes in West Coast Refinery Acquisition Cost of Crude Oil from Domestic and Foreign Sources, by ANS Export Level, 1988 and 1995 (Constant 1988 dollars per Barrel)

Source of Crude	Maximum Allowable Level of ANS Crude Oil Exports				
	400 MB/d	800 MB/d	No Ban	400 MB/d	No Ban
	1988			1995	
Domestic	$0.25	$0.89	$1.85	$0.08	$0.08
Imported	.02	-.12	.55	-.02	-.02
Total	.23	.87	1.92	.11	.11

Note: The increase in the cost of all crude acquired by West Coast refineries usually exceeds the change in the costs of either of the two component crudes because of changes in the relative volumes of those crudes. Specifically, the increase in the cost of all crude is the difference in the weighted averages of the individual cost <u>levels</u> rather than the weighted average differences in those levels. The weights are the volumes of individual crudes acquired by refineries on the West Coast and the volumes change according to the maximum allowable level of ANS crude oil exports.

Source: TRIP model solutions.

Implications for Petroleum Products

World demand for refined petroleum products is expected to continue to grow over the 1988 to 1995 period. Growth will likely be faster in the Pacific Basin countries than on the U.S. West Coast. Total petroleum demand could grow by over 15 percent in Australia/New Zealand and by over 20 percent in the other Pacific Basin countries, with only about 5 percent on the West Coast. This would result in an increased consumption of refined products of almost 2 million barrels per day in the Pacific Basin versus an increase of only about 100 thousand barrels per day on the West Coast. Although total product demand will increase, the market share for individual products, including gasoline, is expected to remain about the same within each of the two regions.

Gasoline market shares are expected to continue to remain small in the Pacific Basin and large on the West Coast over the 1988 to 1995 period. The small changes in gasoline's market share that do occur are not expected to alter the competitiveness of ANS crude oil, which produces only a very small fraction of gasoline-range products. For example, while daily Japanese demand for gasoline is expected to grow by 200 thousand barrels from 1988 to 1995, daily total product demand in that country should grow by about one million barrels, leaving gasoline market shares essentially unchanged.[4]

The elimination of the ANS crude oil export ban is not likely to greatly affect West Coast petroleum product markets in terms of prices, aggregate refinery output, or trade. Increases in product prices would be constrained by the use of a revised crude slate that would reduce processing costs and largely offset the increase in refinery acquisition costs. Aggregate refinery output is not expected to change substantially in the year in which the ban is eliminated but the composition of the output would likely shift to lighter products consistent with the product demand slate on the West Coast. International product trade involving the West Coast is expected to decline as import requirements for light products and exports of heavier products both decrease. The effects in 1988 on West Coast product markets resulting from the elimination of the ban in that year would be greater than if the ban were eliminated in 1995 since West Coast markets would be closer to free-trade conditions in the latter year.

On average, the weighted average increase in product prices is estimated to be about 1 cent per gallon in 1988 if the ban had been fully eliminated in that year and would decrease by a smaller amount if the ban were eliminated in 1995. The different direction of product price change in the 2 years basically results from differences in the magnitudes of crude oil price increases.

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[4]The East-West Center, a national educational center which focuses on energy markets in the Pacific Rim, also projects that product market shares for the West Coast, Japan, and the Asia-Pacific regions will be relatively unchanged to 1995. Those projections are consistent with MITI's 1989-1994 projections for Japanese fuel shares. See East-West Center Petroleum Advisory No. 43: World Oil Supply and Demand Outlook to 2000 (Honolulu, Hawaii, October 1989) and Japanese Ministry of International Trade and Industry (MITI), 5-Year Petroleum Supply Plan (Japan, April 1990).

Gasoline accounts for the bulk of refinery output on the West Coast and residual fuel oil for most of the remainder. If the ban had been eliminated in 1988, the refinery gate price of gasoline in that region could have increased by about $0.50 per barrel (or slightly more than 1 cent per gallon) in that year and the price of residual by slightly less (Table 11). The estimated smaller rise in residual fuel oil prices than in gasoline prices reflects the fact that West Coast refineries would produce residual fuel from less expensive crude streams such as Arab Light, while gasoline would be produced from more expensive streams. Although the results are somewhat different for 1995, the price changes involved are quite small, reflecting the fact that ANS crude prices would quite likely have already risen close to free-market levels in that year even with the ban in effect and that the elimination of the ban would have little effect on refinery acquisition costs and product prices.

Table 11. West Coast Refinery Gate Product Prices at Various ANS Export Levels, 1988 and 1995

Maximum Allowable ANS Crude Oil Exports (MB/d)	Product Prices (Constant 1988 Dollars per Barrel)			
	Premium Gasoline	87 Octane Unleaded	High-Sulfur Residual	Low-Sulfur Residual
		1988		
Base	$22.26	$20.80	$14.74	$15.03
200	22.22	20.77	14.74	15.03
400	22.21	20.76	14.72	14.97
600	22.22	20.80	14.76	14.99
800	22.38	20.92	14.78	14.97
1,000	22.65	21.08	14.88	15.09
1,200	22.79	21.21	15.06	15.26
1,400	22.80	21.27	15.17	15.36
Unbounded	22.80	21.28	15.23	15.41
		1995		
Base	28.83	27.28	20.36	20.65
200	28.62	27.23	20.47	20.74
400	28.47	27.13	20.31	20.74
Unbounded	28.47	27.13	20.31	20.74

Source: TRIP model solutions.

The use of crudes in West Coast refineries that are better suited to meet final product demands in that area affects product trade. West Coast product imports could have declined by 55 thousand barrels per day to 130 thousand barrels per day in 1988 if the ban had been eliminated in that year, depending on whether ANS crude oil exports are assumed to have been at the 800 thousand barrel per day level or at the unrestricted level of 1.5 million barrels per day, respectively (Table 12 and Figure 8). Most of the curtailment in product imports at the unrestricted crude oil export level is likely to have been in unleaded gasoline, reflecting the increased West Coast production of that product. Product imports would decline by a smaller volume in 1995, about 65 thousand barrels per day at the unrestricted ANS export level (Table 12 and Figure 9). The entire reduction would be in unleaded gasoline.

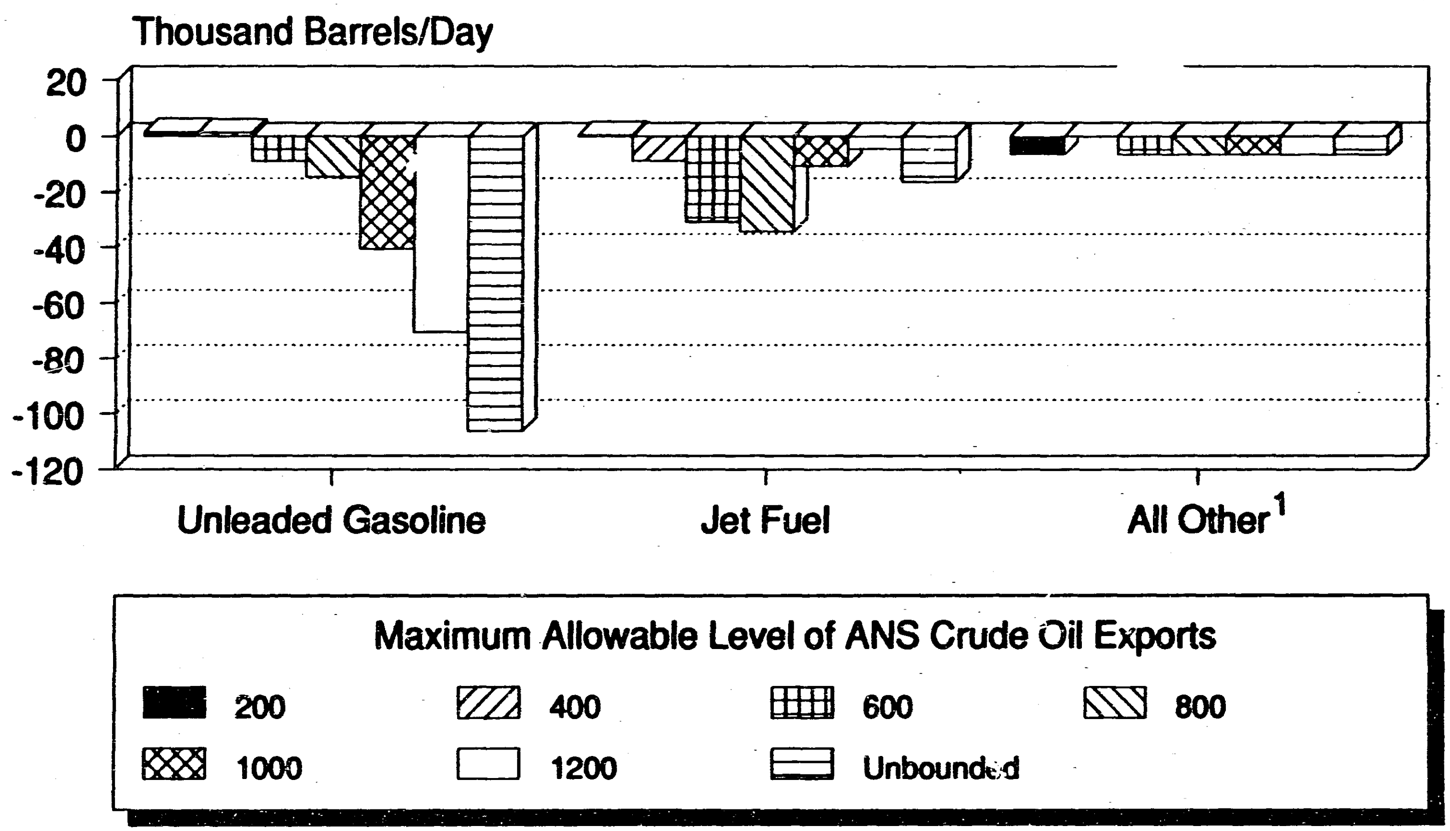
Table 12. Changes in Petroleum Product Imports into the West Coast at Various ANS Crude Oil Export Levels, by Type of Product, 1988 and 1995 (Thousand Barrels per Day)

Maximum Allowable ANS Crude Oil Exports (MB/d)	Product			
	Unleaded Gasoline	Jet Fuel	All Other	Total
		1988		
200	2	1	-7	-5
400	1	-9	0	-8
600	-9	-31	-7	-46
800	-15	-34	-7	-55
1,000	-41	-11	-7	-58
1,200	-70	-5	-7	-82
1,400	-92	-12	-7	-110
Unbounded	-106	-16	-7	-129
		1995		
200	-30	0	0	-30
400	-66	0	0	-66
Unbounded	-66	0	0	-66

Notes: o Sum of components may not equal total due to independent rounding. o May include changes in shipments into the West Coast from other PAD districts.

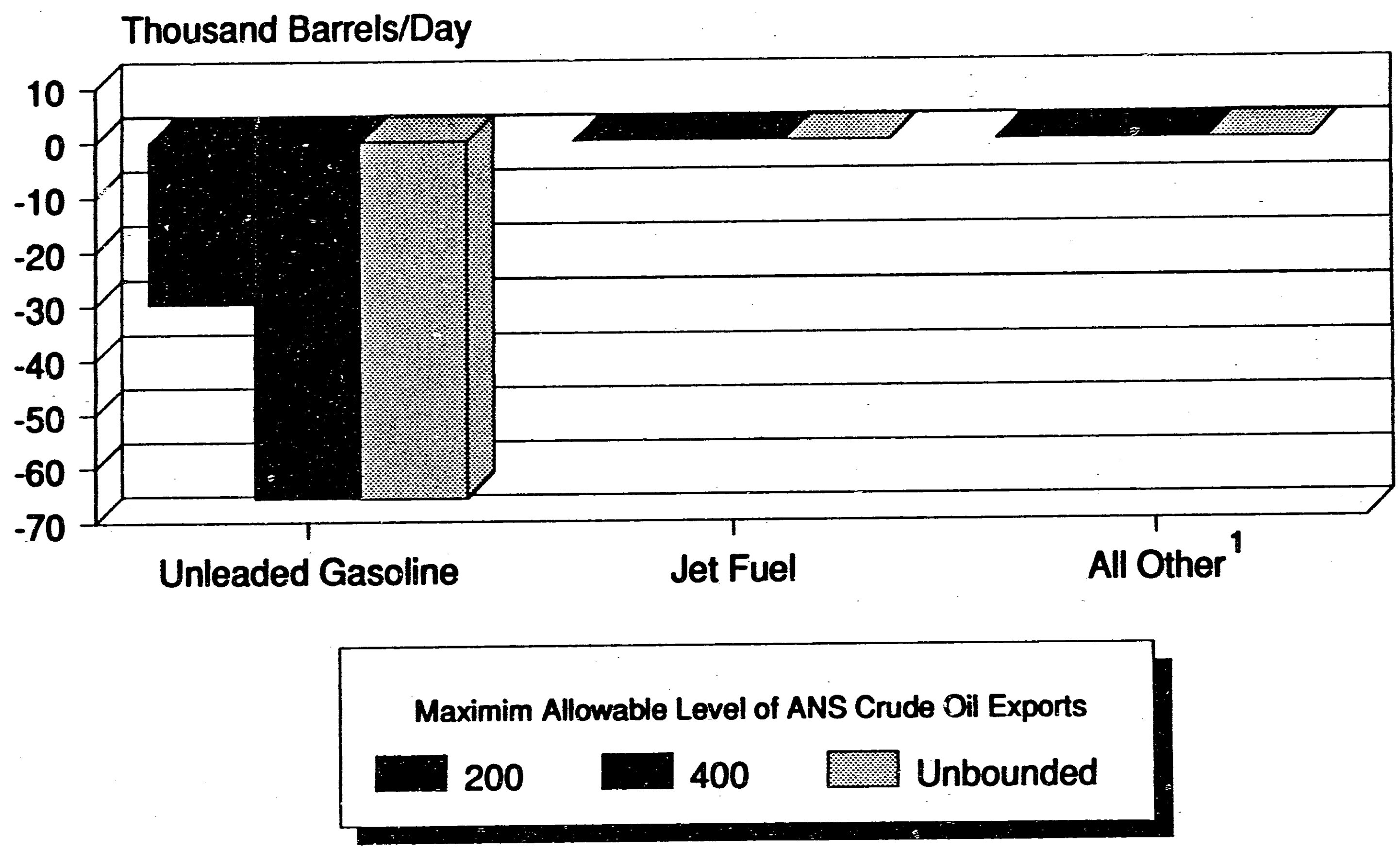
Source: TRIP model solutions.

Figure 8. Changes in Product Imports on the West Coast at Various ANS Export Levels in 1988



[1] All Other includes all product imports other than unleaded gasoline and jet fuel.
Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: TRIP model solutions.

Figure 9. Changes in Product Imports on the West Coast at Various ANS Export Levels, Projected 1995



[1] All Other includes all product imports other than unleaded gasoline and jet fuel.
Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: TRIP model solutions.

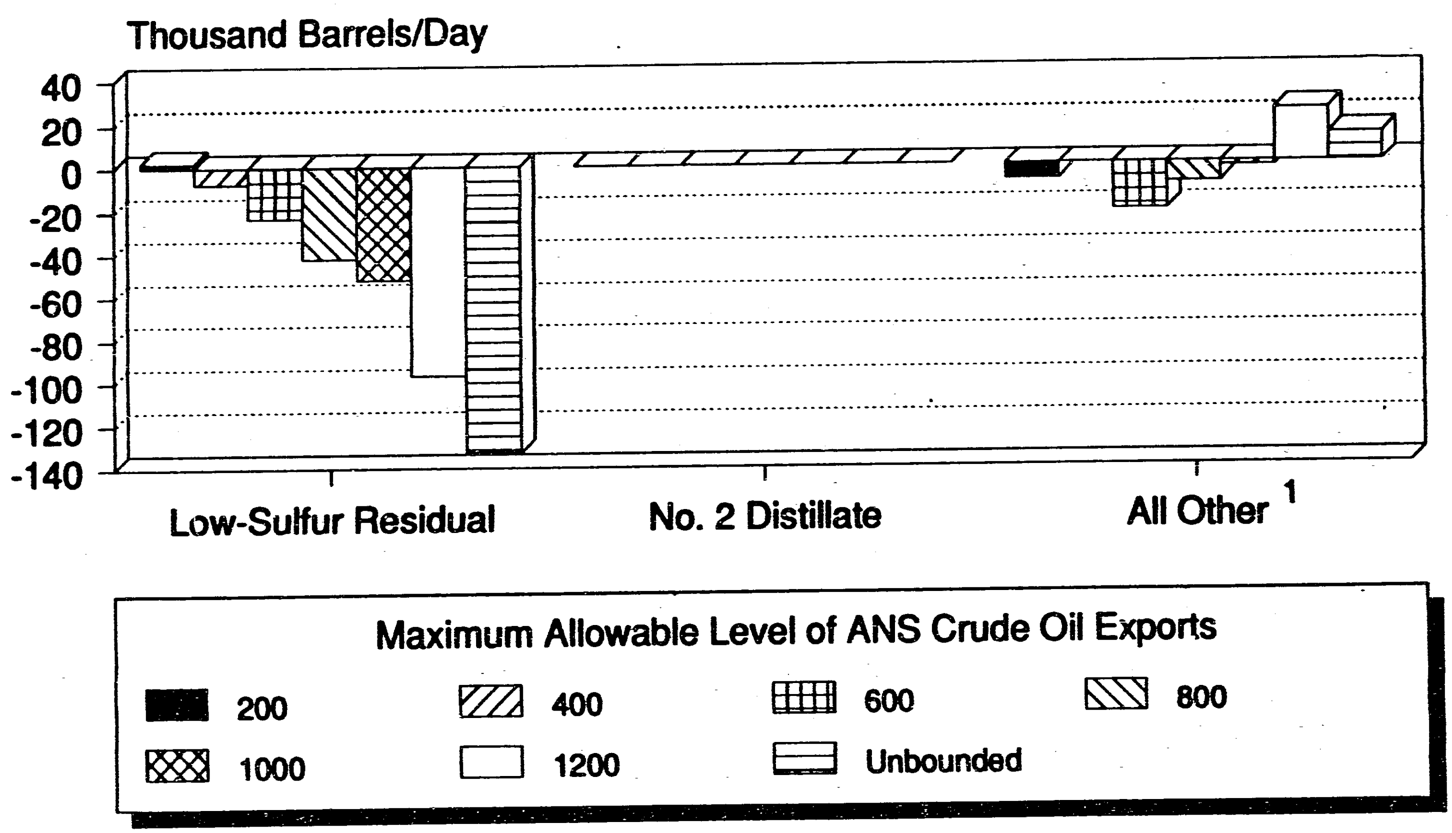
West Coast total product exports are estimated to decline in amounts roughly equal to the decline in product imports. The decrease in 1988 would likely have been principally in low sulfur residual, the production of which would have declined as more gasoline was produced in West Coast refineries. The amount of cutback in the export of that product is directly related to the volume of ANS exports. The cutback could have reached 130 thousand barrels per day (at the unrestricted ANS crude oil export level) in 1988 (Table 13 and Figure 10). The cutback in product exports in 1995 would likely be substantially smaller and would likely be almost entirely in No. 2 distillate oil (Table 13 and Figure 11).

Table 13. Changes in Petroleum Product Exports from the West Coast at Various ANS Crude Oil Export Levels, by Type of Product, 1988 and 1995 (Thousand Barrels per Day)

Maximum Allowable ANS Crude Oil Exports (MB/d)	Product			
	Low-Sulfur Residual	No. 2 Distillate	All Other	Total
		1988		
200	2	0	-7	-5
400	-7	0	0	-7
600	-23	0	-21	-44
800	-42	0	-9	-51
1.000	-52	0	-2	-54
1,200	-97	0	24	-73
1,400	-118	0	17	-102
Unbounded	-133	0	13	-120
		1995		
200	-3	-26	1	-29
400	1	-67	3	-63
Unbounded	0	-67	4	-63

Notes: o Sum of components may not equal total due to independent rounding. o May include changes in shipments from the West Coast to other PAD districts.
Source: TRIP model solutions.

Figure 10. Changes in Product Exports from the West Coast at Various ANS Export Levels in 1988

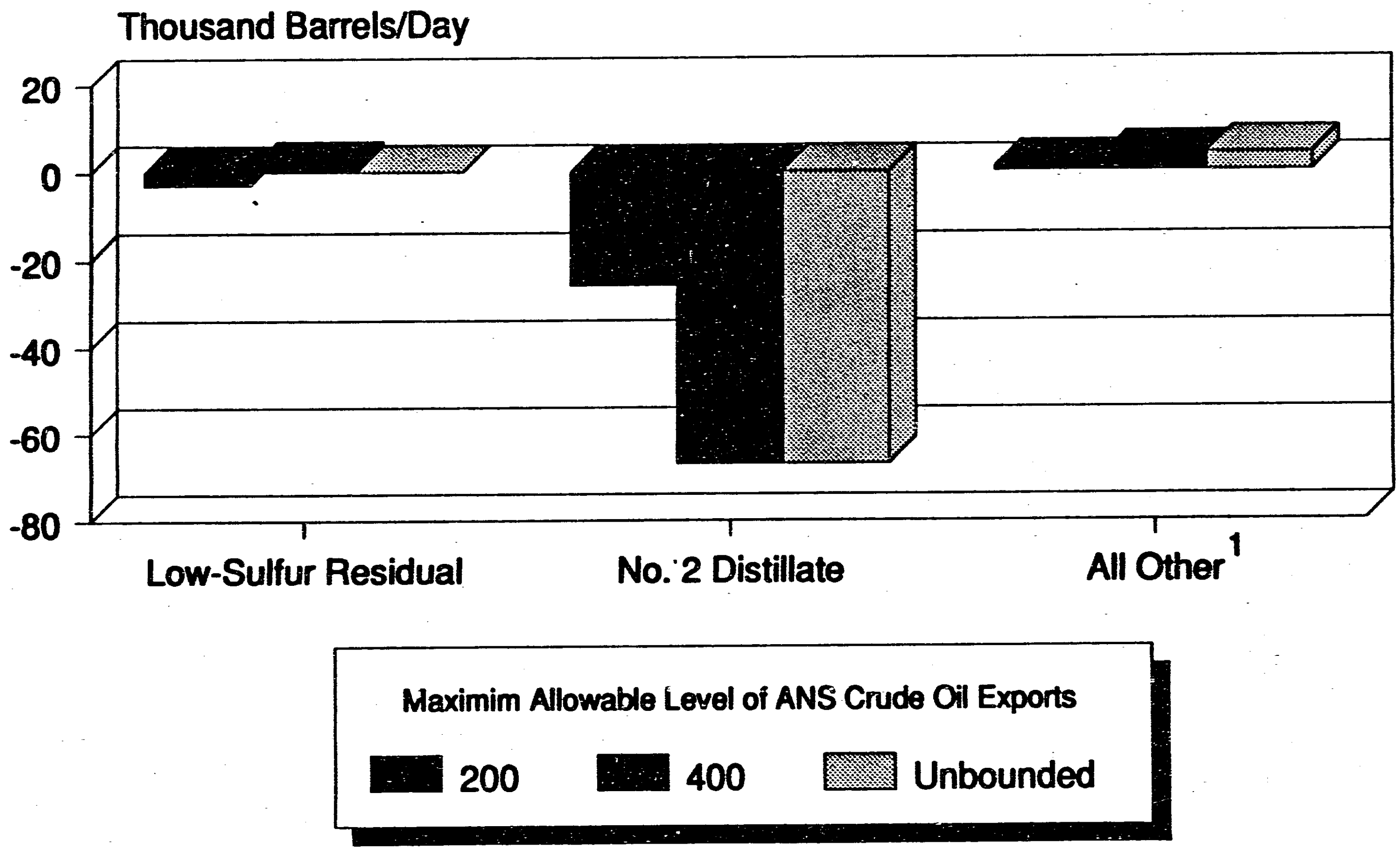


[1] All Other includes all product exports other than low-sulfur residual and No. 2 distillate.

Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).

Source: TRIP model solutions.

Figure 11. Changes in Product Exports from the West Coast at Various ANS Export Levels, Projected 1995



[1] All Other includes all product exports other than low-sulfur residual and No. 2 distillate.
Note: West Coast refers to Petroleum Administration for Defense District V (PADD V).
Source: TRIP model solutions.

Summary of Effects

The price of ANS crude on the West Coast could increase if the ANS export ban were eliminated. The increase reflects the higher value placed on that crude by refiners in the Pacific Basin, since ANS crude is better suited to produce the middle distillates that are in relatively great demand in that area than it is to produce gasoline on the West Coast. The increase in the price of ANS crude would probably have been substantial if the ban had been eliminated in 1988. The increase is likely to be minimal if it is lifted in 1995, since the expected continued decrease in the production of Alaskan crude oil will already have resulted in a substantial price increase by that year. Product prices on the West Coast would not likely change substantially in either year for two reasons. First, the crudes that would be imported into the West Coast to compensate for the exports would be better suited to produce gasoline than is ANS crude. Refinery processing costs would therefore decrease. Second, the existing unconstrained trade in petroleum products places effective limits on product price increases.

The effects on West Coast crude and product flows that could result from eliminating the ban are summarized in Table 14. By assumption, crude oil production in any given year is not affected by the increase in ANS or other crude oil prices, and product demand is also fixed at the base case (no ANS crude oil exports) level. The total amount of crude oil available to the West Coast remains constant in any given year as crude oil imports increase to compensate for the ANS volumes exported. West Coast product imports and exports both decline. The decrease in product imports reflects the increased West Coast refinery production of gasoline as more suitable crudes are imported. The decrease in product exports reflects the decrease in West Coast production of residual and distillate fuels as more gasoline is produced.

Table 14. Petroleum Supply and Demand Balances on the West Coast at Various ANS Export Levels, 1988 and 1995
(Thousand Barrels per Day)

	Maximum Allowable Level of ANS Crude Oil Exports						
Supply/Demand	Full Ban	400 MB/d	800 MB/d	No Ban	Full Ban	400 MB/d	No Ban
	1988				1995		
Supply:							
Crude Production[a]	3,164	3,164	3,164	3,164	2,259	2,259	2,259
Imported Crude[b]	225	225	415	1,140	916	1,316	1,322
Exported Crude[c]	689	689	879	1,604	25	425	431
Imported Product[b]	405	398	350	276	161	95	95
Exported Product[c]	526	520	475	406	643	580	580
Refinery Gain	162	163	166	171	178	181	181
Stock Draw	13	13	13	13	2	2	2
Total Supply	2,754	2,754	2,754	2,754	2,847	2,847	2,847
Demand:							
Gasoline	1,253	1,253	1,253	1,253	1,284	1,284	1,284
Distillate	423	423	423	423	446	446	446
Residual	268	268	268	268	286	286	286
Jet Fuel	404	404	404	404	424	424	424
LPG's	79	79	79	79	89	89	89
Other Products	287	287	287	287	319	319	319
Crude Oil	40	40	40	40	0	0	0
Total Demand	2,754	2,754	2,754	2,754	2,847	2,847	2,847

[a]Includes natural gas liquids, other production, and unaccounted for.
[b]Shipments into the West Coast from other domestic regions and from foreign countries.
[c]Shipments from the West Coast to other domestic regions and to foreign countries.
Note: Sum of components may not equal total due to independent rounding.
Source: TRIP model solutions.

5. LIMITATIONS AND QUALIFICATIONS

There is uncertainty concerning the actual effects that would occur if the ban on Alaskan crude oil were eliminated. No model can be expected to precisely capture all of the behavioral reactions and technological adjustments that would ensue. The best that can be expected is an indication of the direction and general order of magnitude of those effects. The results presented in this study should be viewed in that light rather than as highly accurate point estimates.

The uncertainty concerning the magnitude of the effects results, in large part, from limitations of the TRIP model and the assumptions made. Three that are integral to the model are particularly noteworthy. They relate to instantaneous adjustment, feedback effects, and refinery aggregation.

The first of these model limitations relates to the speed of adjustment. The effects of eliminating the ban are instantaneously transmitted throughout much of the petroleum economy. The effects associated with unconstrained ANS export levels may therefore be overstated, at least for 1988 where the unconstrained level is large. To account for this limitation, the volume of ANS crude oil exports was constrained at various levels to provide a range of uncertainty and to analyze the sensitivities to alternative export levels.

The second model limitation relates to feedback effects. In reality, developments in the petroleum economy impact on other energy and nonenergy sectors, which in turn affect the petroleum economy. The model does not capture these feedback effects since petroleum is essentially the only energy resource sector in the model. These feedback effects would probably be small during the years in which the ban is eliminated.

A third limitation that is integral to the model relates to the aggregation of refineries. The model consists of 33 world regions, each of which is represented by a single refinery. This is a great simplification of reality. For example, the West Coast region contains about 50 refineries, and a single representation of those refineries may lead to different results than would occur in the real world. Due to this limitation, the magnitude of the price effects are subject to considerably more uncertainty than are the crude volume effects.

Many of the additional limitations relate to the assumptions incorporated into the model rather than to the model itself. For example, the volume of ANS crude oil production is set at the level forecasted with the ban in effect. The level is not altered to reflect the likely increase in production that would occur in reaction to higher prices if the ban were eliminated. It is estimated that any increase in production would be small during the year the ban is eliminated. Further, sensitivity analysis indicates that any such increase in production would be exported, with few additional effects. In particular, there would be little further change in either the price of ANS crude on the West Coast or in the compensating volume of crude oil imported into that region.

Final product demand in each of the world's 33 refinery regions is assumed to be invariant with respect to any given level of ANS exports during the year in which the ban is eliminated. In reality, product demand should respond to the ensuing change in product prices. Since the relative and absolute changes in product prices are small (about 1 cent per gallon or less), the potential effects on the level and composition of product demand are probably also small. (Although the level and composition of product demand are fixed for any given year, they are set at different levels in 1988 and 1995.)

A major assumption is that refinery capacity in each region is the same in 1995 as in 1988. As a result, 1995 capacity utilization is generally at 100 percent in U.S. refinery regions and at or near 100 percent in most other regions. The almost complete capacity utilization reflects not only the fixed capacity assumption but also the assumptions that final product demand and crude oil production will both be greater in 1995 than in 1988. As a result, model-generated ANS crude exports and petroleum product imports into the U.S. West Coast in 1995 are probably greater than they would be if capacity were greater. However, the constraint on capacity is not entirely unrealistic since there will likely be little growth in capacity, at least in the United States, to 1995. The constraint on capacity within the model probably caused product prices to be slightly higher than they would otherwise be in that year, while putting downward pressure on crude prices.

Ocean transportation costs add significantly to the delivered price of crude petroleum and products. Generally, it was assumed that these costs were the same (in constant 1988 dollars) in 1995 as in 1988. The one exception is that the bunker fuel component of the costs was changed for 1995. The assumption of essentially constant transportation costs probably understates the costs that will actually exist in 1995 and, therefore, the delivered price of much of the oil sold on world markets. The reason is that substantial increases in production by members of the Organization of Petroleum Exporting Countries (OPEC) are expected by that year, and the associated increase in demand for tanker services could cause transportation rates to rise.

The net effect of these limitations and qualifications on the results generated by the TRIP model is probably not great. Although the effects of lifting the export ban would undoubtedly differ somewhat from those presented here, the general order of magnitude of the estimated effects are considered representative of actual energy markets.

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