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Volume VII

SEASAT ECONOMIC ASSESSMENT

MARINE TRANSPORTATION CASE STUDY

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Volume VII

SEASAT ECONOMIC ASSESSMENT

MARINE TRANSPORTATION CASE STUDY

Prepared for

National Aeronautics and Space Administration
The Office of Applications
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Washington, D.C.
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October 1975

NOTE OF TRANSMITTAL

The SEASAT Economic Assessment was performed for the Special Programs Division, Office of Applications, National Aeronautics and Space Administration, under contract NASW-2558. The work described in this report began in February 1974 and was completed in August 1975.

The economic studies were performed by a team consisting of Battelle Memorial Institute; the Canada Centre for Remote Sensing; ECON, Inc.; the Jet Propulsion Laboratory; and Ocean Data Systems, Inc. ECON, Inc. was responsible for the planning and management of the economic studies and for the development of the models used in the generalization of the results.

This volume presents case studies and their generalization concerning the economic benefits of improved ocean condition and weather forecasts to marine transportation.

The Marine Transportation case studies and generalization were performed by ECON, Inc. Dr. William Steele of ECON, Inc. was the principal investigator for the Marine Transportation Study and the author of this report. A complimentary study of Marine Transportation benefits to Canada was performed by the Canada Centre for Remote Sensing and is incorporated in this report. The Canadian study was performed by Mr. D. Clough, Dr. J. C. Henein and Dr. A. McQuillan.

The SEASAT Users Working Group (now Ocean Dynamics Subcommittee) chaired by Dr. John Apel of the National Oceanographic and Atmospheric Administration, served as a valuable source of information as a forum for the review of these studies. Mr. S.W. McCandless, the SEASAT Program Manager, coordinated the activities of the many organizations that participated in these studies into the effective team that obtained the results described in this report.

B.P. Miller

SUMMARY AND CONCLUSIONS OF THE MARINE TRANSPORTATION CASE STUDY

The studies conducted of the potential use of SEASAT ocean condition data and resulting forecasts by dry cargo ships and tankers reached the following conclusions. The SEASAT ocean condition data and resulting forecasts could be usefully employed to route ships around storms, thereby resulting in reduced adverse weather damage, time loss and the related operating costs, and occasional catastrophic losses. These benefits are incremental benefits beyond those which present and future conventional ship routing procedures can supply. The values of these benefits are as follows:

- Reduction in delay time on all U.S. trade routes yields annual undiscounted benefits of approximately $20,660,000 for dry cargo ships
- Reduction in delay time on all U.S. trade routes yields cumulative discounted benefits, 1985-2000, of approximately $86,620,000 for dry cargo ships
- Reduction in hull damage on all U.S. trade routes yields annual, undiscounted benefits of approximately $6,400,000 for dry cargo ships
- Reduction in hull damage on all U.S. trade routes yields cumulative discounted benefits, 1985-2000, of approximately $26,840,000 for dry cargo ships
- Reduction in delay time on Canadian trade routes yields annual undiscounted benefits of $6,440,000 to $9,220,000 for dry cargo ships
- Reduction in delay time on Canadian trade routes yields cumulative discounted benefits, 1985-2000, of $25,200,000 to $43,800,000 for dry cargo ships
- Reduction in marine insurance costs for dry cargo ships on Canadian trade routes yields annual undiscounted benefits of $5,000,000 to $34,900,000

- Reduction in marine insurance costs for dry cargo ships on Canadian trade routes yields cumulative discounted benefits of $24,500,000 to $163,600,000

- Reduction in delay time on all major world routes yields annual undiscounted benefits of $3,430,000 to $16,680,000 for the world tanker fleet

- Reduction in delay time on all major world routes yields cumulative discounted benefits of $19,400,000 to $94,250,000 for the world tanker fleet

- Reduction in catastrophic losses on all major world routes yields annual undiscounted benefits of $5,830,000 to $19,420,000 for the world tanker fleet

- Reduction in catastrophic losses on all major world routes yields cumulative discounted benefits, 1985-2000, of $32,930,000 to $109,800,000 for the world tanker fleet

- Overall annual undiscounted benefits are $47,760,000 to $107,280,000

- Overall cumulative discounted benefits, 1985-2000, are $215,490,000 to $524,910,000.

These overall results are presented in tabular form on page 143. All figures are in 1975 U.S. dollars. The annual figures presented above are for the first fully operational year for SEASAT, 1985. The discount rate used is 10% in all cases.

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This report, consisting of ten volumes, represents the results of the SEASAT Economic Assessment, as completed through August 31, 1975. The individual volumes in this report are:

- Volume I - Summary and Conclusions
- Volume II - The SEASAT System Description and Performance
- Volume III - Offshore Oil and Natural Gas Industry - Case Study and Generalization
- Volume IV - Ocean Mining - Case Study and Generalization
- Volume V - Coastal Zones - Case Study and Generalization
- Volume VI - Arctic Operations - Case Study and Generalization
- Volume VII - Marine Transportation - Case Study and Generalization
- Volume VIII - Ocean Fishing - Case Study and Generalization
- Volume IX - Ports and Harbors - Case Study and Generalization
- Volume X - A Program for the Evaluation of Operational SEASAT System Costs.

Each volume is self-contained and fully documents the results in the study area corresponding to the title. Table 1.1 describes the content of each volume to aid readers in the selection of material that is of specific interest.

The SEASAT Economic Assessment began during Fiscal Year 1975. The objectives of the preliminary economic assessment, conducted during Fiscal Year 1975, were to identify the uses and users of the data that could be produced by an operational SEASAT system and to provide preliminary estimates of the benefits produced by the applications of this

Table 1.1: Content and Organization of the Final Report

Volume No.	Title	Content
I	Summary and Conclusions	A summary of benefits and costs, and a statement of the major findings of the assessment.
II	The SEASAT System Description and Performance	A discussion of user requirements, and the system concepts to satisfy these requirements are presented along with a preliminary analysis of the costs of those systems. A description of the plan for the SEASAT data utility studies and a discussion of the preliminary results of the simulation experiments conducted with the objective of quantifying the effects of SEASAT data on numerical forecasting.
III	Offshore Oil and Natural Gas Industry-Case Study and Generalization	The results of case studies which investigate the effects of forecast accuracy on offshore operations in the North Sea, the Celtic Sea, and the Gulf of Mexico are reported. A methodology for generalizing the results to other geographic regions of offshore oil and natural gas exploration and development is described along with an estimate of the world-wide benefits.
IV	Ocean Mining - Case Study and Generalization	The results of a study of the weather sensitive features of the near shore and deep water ocean mining industries are described. Problems with the evaluation of economic benefits for the deep water ocean mining industry are attributed to the relative immaturity and highly proprietary nature of the industry.

Table 1.1: Content and Organization of the Final Report
(continued)

Volume No.	Title	Content
V	Coastal Zones - Case Study and Generalization	The study and generalization deal with the economic losses sustained in the U.S. coastal zones for the purpose of quantitatively establishing economic benefits as a consequence of improving the predictive quality of destructive phenomena in U.S. coastal zones. Improved prediction of hurricane landfall and improved experimental knowledge of hurricane seeding are discussed.
VI	Arctic Operations - Case Study and Generalization	The hypothetical development and transportation of Arctic oil and other resources by ice breaking super tanker to the continental East Coast are discussed. SEASAT data will contribute to a more effective transportation operation through the Arctic ice by reducing transportation costs as a consequence of reduced transit time per voyage.
VII	Marine Transportation-Case Study and Generalization	A discussion of the case studies of the potential use of SEASAT ocean condition data in the improved routing of dry cargo ships and tankers. Resulting forecasts could be useful in routing ships around storms, thereby reducing adverse weather damage, time loss, related operations costs, and occasional catastrophic losses.
VIII	Ocean Fishing - Case Study and Generalization	The potential application of SEASAT data with regard to ocean fisheries is discussed in this case study. Tracking fish populations, indirect assistance in forecasting expected populations and assistance to fishing fleets in avoiding costs incurred due to adverse weather through improved ocean conditions forecasts were investigated.
IX	Ports and Harbors - Case Study and Generalization	The case study and generalization quantify benefits made possible through improved weather forecasting resulting from the integration of SEASAT data into local weather forecasts. The major source of avoidable economic losses from inadequate weather forecasting data was shown to be dependent on local precipitation forecasting.
X	A Program for the Evaluation of Operational SEASAT System Costs	A discussion of the SATIL 2 Program which was developed to assist in the evaluation of the costs of operational SEASAT system alternatives. SATIL 2 enables the assessment of the effects of operational requirements, reliability, and time-phased costs of alternative approaches.

data.* The preliminary economic assessment identified large potential benefits from the use of SEASAT-produced data in the areas of Arctic operations, marine transportation, and offshore oil and natural gas exploration and development.

During Fiscal Year 1976, the effort was directed toward the confirmation of the benefit estimates in the three previously identified major areas of use of SEASAT data, as well as the estimation of benefits in additional application areas. The confirmation of the benefit estimates in the three major areas of application was accomplished by increasing both the extent of user involvement and the depth of each of the studies. Upon completion of this process of estimation, we have concluded that substantial, firm benefits from the use of operational SEASAT data can be obtained in areas that are extensions of current operations such as marine transportation and offshore oil and natural gas exploration and development. Very large potential benefits from the use of SEASAT data are possible in an area of operations that is now in the planning or conceptual stage, namely the transportation of oil, natural gas, and other resources by surface ship in the Arctic regions. In this case, the benefits are dependent upon the rate of development of the resources that are believed to be in the Arctic regions, and also dependent upon the choice of surface transportation over pipelines as the means of moving these resources to the lower

*SEASAT Economic Assessment, ECON, Inc., October 1974.

latitudes. Our studies have also identified that large potential benefits may be possible from the use of SEASAT data in support of ocean fishing operations. However, in this case, the size of the sustainable yield of the ocean remains an unanswered question; thus, a conservative viewpoint concerning the size of the benefit should be adopted until the process of biological replenishment is more completely understood.

With the completion of this second year of the SEASAT Economic Assessment, we conclude that the cumulative gross benefits that may be obtained through the use of data from an operational SEASAT system, to provide improved ocean condition and weather forecasts is in the range of $859 million to $2,709 million ($1975 at a 10 percent discount rate) from civilian activities. These are gross benefits that are attributable exclusively to the use of SEASAT data products and do not include potential benefits from other possible sources of weather and ocean forecasting that may occur in the same period of time. The economic benefits to U.S. military activities from an operational SEASAT system are not included in these estimates. A separate study of U.S. Navy applications has been conducted under the sponsorship of the Navy Environmental Remote Sensing Coordinating and Advisory Committee. The purpose of this Navy study was to determine the stringency of satellite oceanographic measurements necessary to achieve improvements in military mission effectiveness in areas where benefits are known to exist.* It is currently planned that the Navy will use SEASAT-A data to quantify benefits in military applications areas. A one-time military benefit of approximately $30 million will be obtained by SEASAT-A, by providing a measurement capability in support of the Department of Defense Mapping, Charting and Geodesy Program.

Preliminary estimates have been made of the costs of an operational SEASAT program that would be capable of producing the data needed to obtain these benefits. The hypothetical operational program used to model the costs of an operational SEASAT system includes SEASAT-A, followed by a number of developmental and operational demonstration flights, with full operational capability commencing in 1985. The cost of the operational SEASAT system through 2000 is estimated to be about $753 million ($1975, 0 percent discount rate) which is the equivalent of $272 million ($1975) at a 10 percent discount rate. It should be noted that this cost does not include the costs of the program's unique ground data handling equipment needed to process, disseminate or utilize the information produced from SEASAT data. Figures 1.1 and 1.2 illustrate the net cumulative SEASAT exclusive benefit stream (benefits less costs) as a

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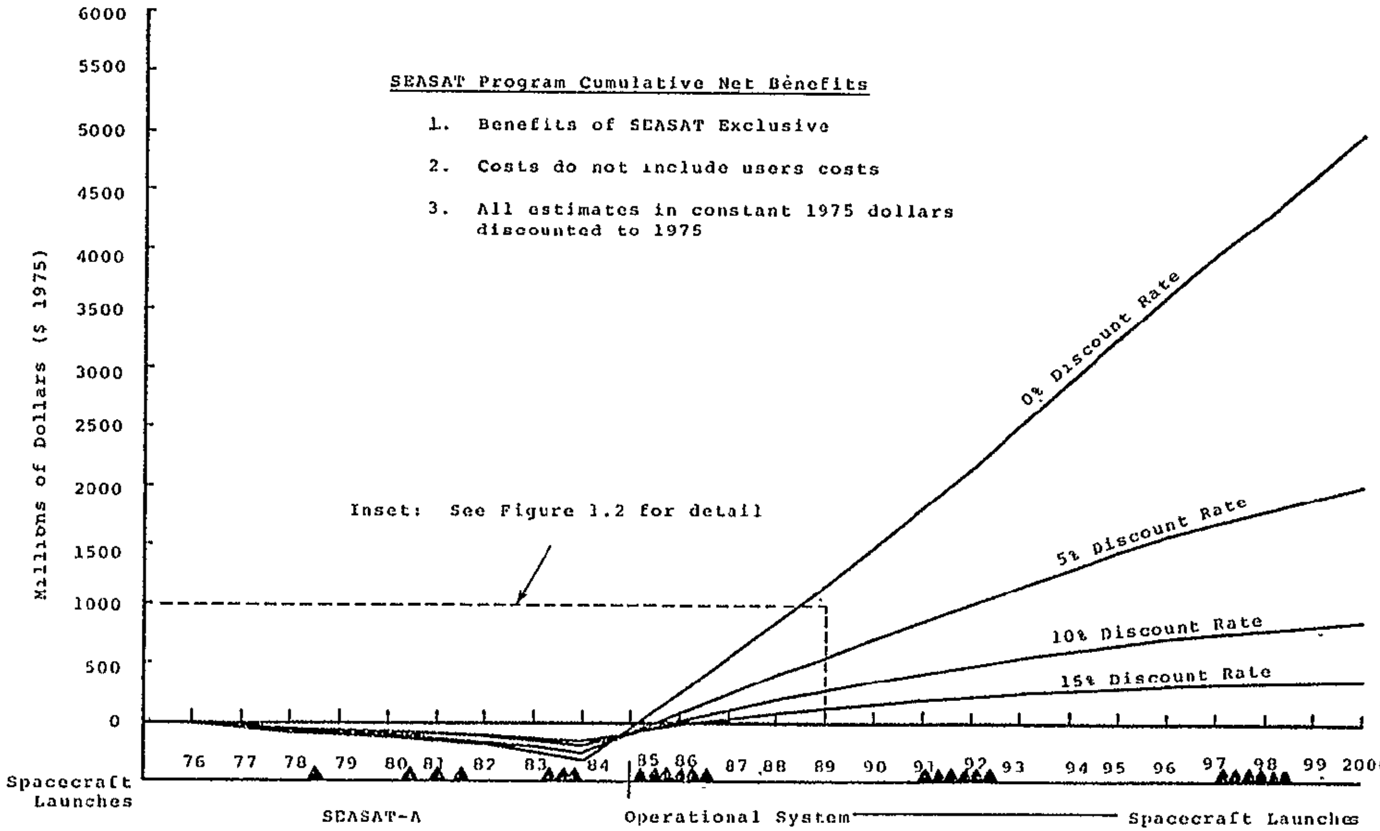
* "Specifications of Stringency of Satellite Oceanographic Measurements for Improvement of Navy Mission Effectiveness." (Draft Report.) Navy Remote Sensing Coordinating and Advisory Committee, May 1975.



Costs*	19	49	78	100	123	151	184	239	307	352	368	373	375	393	437	503	546	566	568	587	629	695	738	753
Benefits*										311	622	933	1244	1555	1937	2319	2701	3083	3465	384	4229	4611	5375	5757

*Cumulative Costs and Benefits at 0% Discount Rate (millions, $ 1975)

Figure 1.1 SEASAT Net Benefits, 1975-2000

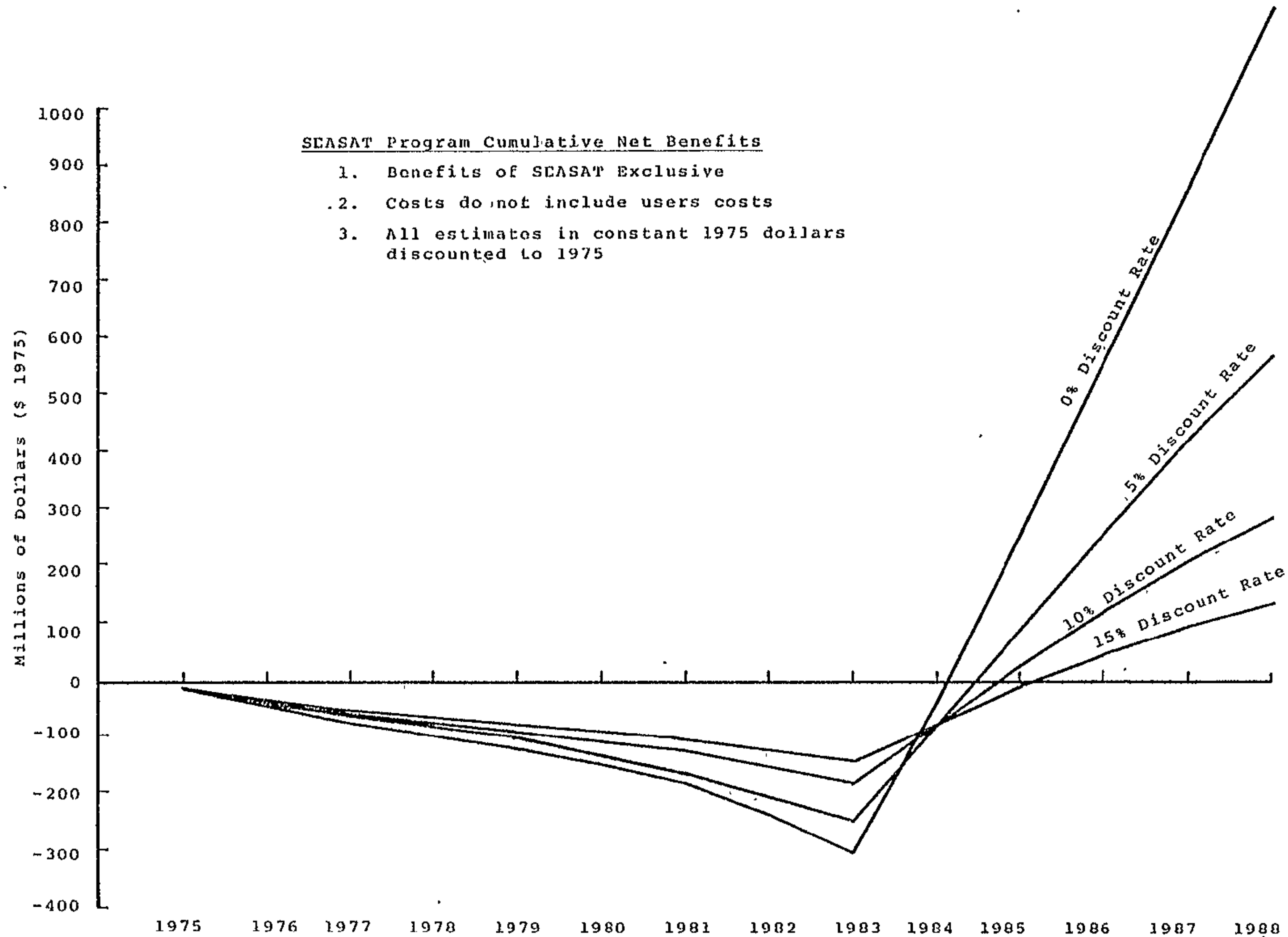


Figure 1.2 SEASAT Net Benefits, Inset

function of the discount rate.

This volume describes the results of the case studies and generalization of the economic benefits of improved forecasts of weather and ocean conditions to the marine transportation industry.

2. INTRODUCTION AND BACKGROUND

2.1 Case Study Approach and Overview

The study estimates the impact of an operational SEASAT system on ocean marine transportation. The areas examined are operating costs, casualty costs, and insurance. In order to measure this impact, several broad questions had to be answered. These questions were:

- What is the total amount of global trade expected in the period 1975-2000?
- What is the total number of ships of each type which will be operating on the major U.S. trade routes in the period 1975-2000?
- What is the probability that a vessel of a given type operating on a given trade route will suffer a weather-related casualty?
- What is the expected cost of such a weather-related casualty?
- What is the impact on time delays and operating costs of attempts to avoid weather-related casualties by such procedures as ship routing?
- What are the weather-related impacts on marine insurance for non-oceangoing shipping?
- What is the impact of SEASAT on marine casualty costs and weather-related operating costs?
- Where are the incidences of costs and benefits realized (to whom will benefits accrue)?

These questions were raised in this case study for three systems which could provide information on ocean conditions and weather over the oceans for use by marine transportation interests:

- The present system - assumes the present system will be operating in the 1985-2000 period. This is the baseline case

- The modified present system - assumes the present system will be improved by advances in forecasting science and data collection for the period 1985-2000

- The SEASAT aided system - assumes the modified present system plus further advances in data collection and forecasting for the period 1985-2000 as a result of the operational SEASAT system

The case study chosen was container ship crossings on the North Atlantic, trade route 05 (between the US and the United Kingdom and Ireland).

The overall approach is illustrated in Figure 2.1, the Marine Transportation Case Study Overview.

It should be noted that the focus of the benefit analysis was on the real side as opposed to the financial side. That is, the study focused on reductions in ship damage, ship operating costs, cargo losses and, in general, in the loss of labor and capital due to weather damage on the oceans. The financial approach, not followed here, would focus on the other side of the same coin, i.e., the reduction in premiums or the increase in profits of the marine insurance firms and/or the shipping companies and/or shippers and/or consumers due to the reductions in real losses. Theoretically, the benefits as measured by either approach should yield the same result. The real approach was chosen because it provided a direct, more accurate, more accessible estimate. The financial side would have required intimate knowledge of competitive conditions in the shipping industry, the marine insurance industry, and the consumer industry.

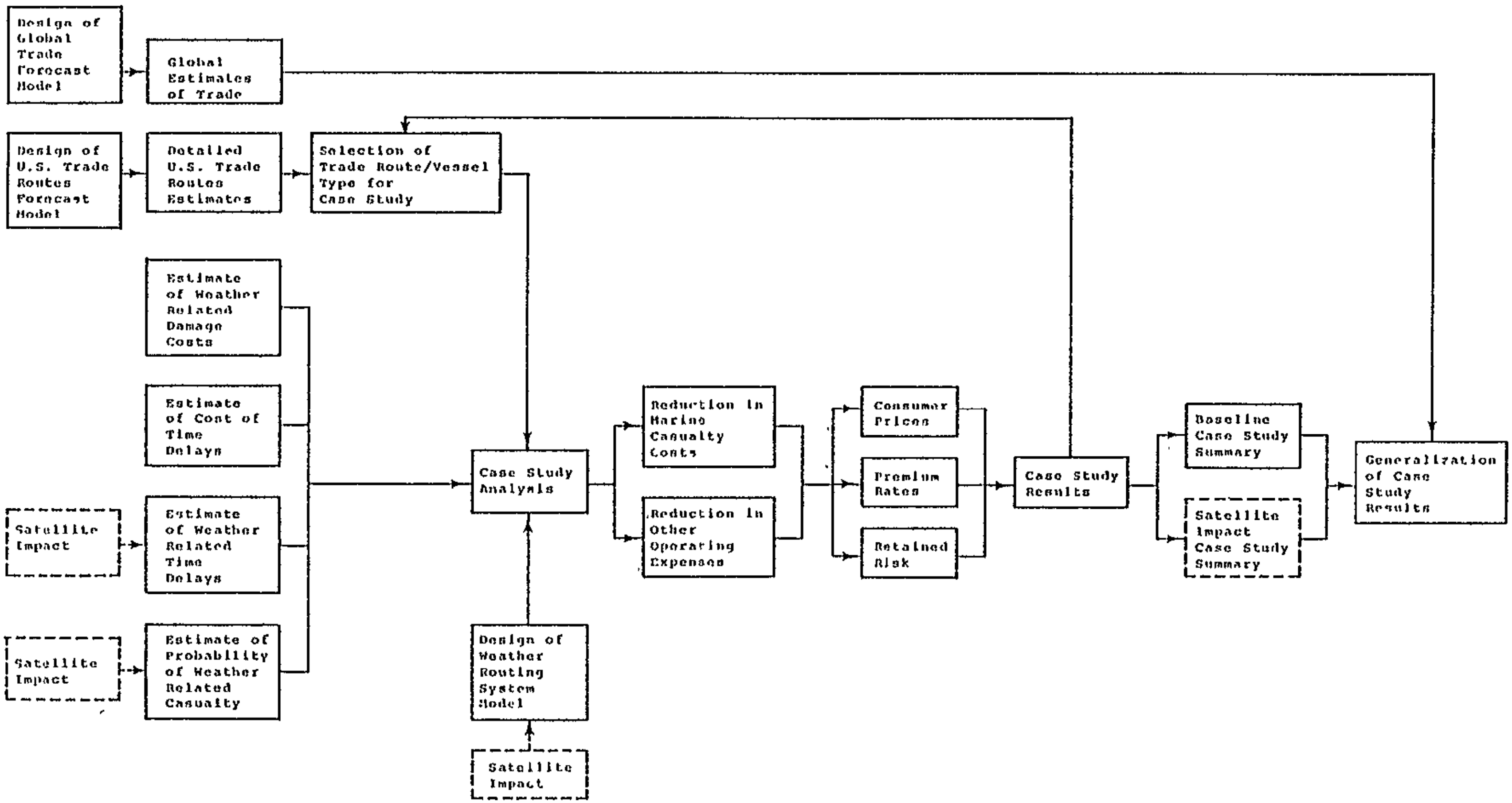


Figure 2.1 Marine Transportation Case Study Overview

2.2 The Volume of World Shipping, 1985-2000

The procedure for generating benefits in each area of the SEASAT economic assessment involves case study analysis followed by generalization of the results of the case study. Accordingly, it was necessary to develop a global forecast of shipping to support the generalization of the marine transportation case study and several of the other case studies in progress or being contemplated. This chapter is devoted to a discussion of the forecasts generated for the generalization process.

In order to make the large step from the case study to the global generalization, it was necessary to fill in some information between these points. Working from the top down, the relative density of the global shipping forecasts for 1985-2000 was developed from the literature by major areas of the oceans and by major vessel type. Working from the bottom up, detailed shipping forecasts, identical to the ones used for the specific vessel type on the specific U.S. trade route in the case studies, were developed for all major U.S. trade routes.

2.2.1 Global Forecasts

The forecast variables needed for the generalization included:

- Quantity of oil shipped
- Number of tankers

- Freight rates (revenues) for tankers for 1985-2000
- Quantity of dry cargo shipped
- Number of dry cargo ships
- Freight rates for dry cargo ships for 1985-2000.

Since oil shipments make up slightly over one-half the value of all cargo shipped in the world and over one-half the volume of cargo shipped in the world and since the explanation of oil flows involves political and economic factors which have changed in some dramatic and discrete steps, it was necessary to keep the forecasts of dry cargo and oil separate. Another substantive consideration which influenced the forecasts was the size of ships, particularly of oil tankers. It was necessary to forecast both the number of ships and the volume shipped in order to capture trends in the size of ships. And, finally, it was necessary to obtain estimates of the revenue flow in shipping. This involved forecasts of freight rate trends. Freight rates are the fundamental unit price in shipping.

A survey of the literature reveals a large number of shipping forecasts. These include:

a. Determination of Shipping Industry Submarkets, Mathematica, July 1972.

b. Domestic Waterborne Shipping Market Analysis, A. D. Little, February 1974.

c. Transportation Cargo Study, Planning Research Corporation, March 1971.

d. Oceanborne Shipping: Demand and Technology Forecast, Litton Systems, June 1968.

e. Position Papers Relating to the New Maritime Program, U.S. Maritime Administration, March 1973.

f. The Impact of the Maritime Containerization on the United States Transportation System, Manalytics, February 1972.

g. A Report to the U.S. Department of Commerce, Maritime Administration for Phase I Ship Design and Program Studies for a U.S. Flag Merchant Fleet, Newport News Shipbuilding and Dry Dock Co., 1970.

h. Isthmian Canal Demand Forecast. An Economic Analysis of Potential Tonnage Traffic, Department of Transportation, 1969.

i. Analysis of Merchant Shipping and International Commodity Flows, Center for Naval Analysis, February 1969.

j. Forecast of U.S. Oceanborne Foreign Trade in Dry Bulk Commodities, Booz-Allen Applied Research, March 1969.

The full reference for each of these studies may be found in the References as [30], [32], [31], [29], [35], [1], [2], [3], [4], and [5], respectively.

However extensive this list may be, none of the individual studies nor a pooling of their results could provide a consistent forecast for 1985-2000 for each of the variables indicated above. Therefore, an econometric model was constructed to make a consistent set of forecasts.

2.2.2 The Econometric Model - Global Forecasts

An eight equation econometric model was constructed. Five of the equations were utilized to make oil forecasts, and three equations were utilized to make dry cargo forecasts. There were eight endogenous variables, i.e., variables solved for within the model. These were:

- Consumption of oil
- Quantity of oil shipped
- Number of tankers
- Active tankers
- Freight rates (revenues) for tankers
- Quantity of dry cargo shipped
- Number of dry cargo ships
- Freight rates for dry cargo ships for 1985-2000.

In the parameter estimation phase, it became necessary to distinguish between active and total number of tankers. Gross tonnage of tankers and dry cargo ships proved better for estimating purposes than the absolute number of ships. However, the number of ships can be obtained directly with an assumption about the future size of ships. One of the endogenous variables, freight rates, was determined by a recursive procedure.

Two exogenous variables, i.e., variables fed into the model, were employed:

- Price of oil per barrel
- Level of world industrial production.

Shipping demand is essentially a derived demand. It is derived from the demand for the goods which are to be shipped. In the case of oil, this involved estimating the consumption demand for world oil as a function of the price per barrel. In the case of dry cargo, it was assumed that the quantity of dry cargo demanded was directly related to the level of world industrial activity which is given exogenously. On the supply side, it was assumed that the most important consideration was the past behavior of freight rates.

These functional relationships involved considerable aggregation and simplification. A thorough analysis would distinguish between liner and tramp service (scheduled and unscheduled service) and between time charter and trip charter service. Shipping supply would also have to be related to capital costs and to operating expenses. These variables are hard to come by or nonexistent. Construction of these series would involve considerable effort with questionable results; see, for example, Dreihuis' [27] construction of an index of operating expenses.

The goal of the effort in this section was to provide accurate forecasts as opposed to obtaining causal explanations of the behavior of the variables in question. Thus, the simple exponential growth model form

$$C = \phi e^{\lambda t}$$

was used whenever it gave a good fit and did not violate common sense considerations. For example, past data on the consumption of oil are fit easily with the basic exponential growth model. But the price of oil per barrel tripled in the last year. Projecting the trend from 1950-1973 to 1985-2000 would be meaningless. Accordingly, the price of oil per barrel was included along with past growth to forecast the consumption of oil:

$$C_{oil} = \phi \, e^{\lambda t} \, P_{oil}^{\alpha 1}.$$

While this did not improve the fit of past data in any significant way, it greatly increased the plausibility of the forecasts.

In addition to limiting the level of disaggregation and relying on growth trends rather than purely causal variables, a number of statistical simplifications were also made. Spectral analysis, which might have yielded some better fitting lag relationships, was not performed; nor were the equations put into first differences; nor was two-stage least squares used to estimate the coefficients.

Each of the disaggregations and statistical improvements mentioned above might have improved the forecasts but at an expense in time and effort which, it was judged, would not be justified by the results. The final form of the eight-equation econometric model used to make the global forecasts is illustrated in Figure 2.2, System of Equations Used to Make Global Forecasts, with the estimated coefficients. The procedure by which these coefficients were estimated is described in the next section.

I. Consumption of Oil (C_{oil}) - in million metric tons of coal equivalent

$$C_{oil} = 668.7e^{.075t} \; P_{oil}^{-.150}$$

II. Quantity of Oil Shipped (Q_{oil}) - in million metric tons

$$Q_{oil} = .0828 \; C_{oil}^{1.223}$$

III. Gross Tonnage of Oil Tankers Supplied (GRT_{oil}) - in million gross tons

$$GRT_{oil} = 109.5e^{.081t} \; FR_{t-2,oil}^{.023} \; FR_{t-4,oil}^{.057}$$

IV. Active Gross Tonnage of Oil Tankers ($AGRT_{oil}$) - in million gross tons

$$AGRT_{oil} = .9071 \; Q_{oil}^{.542} \; GRT_{oil}^{.433}$$

V. Freight Rates for Tankers ($FR_{t,oil}$) - index

$$FR_{t,oil} = 98.64 \; (AGRT_{oil}/GRT_{oil})^{6.040}$$

VI. Quantity of Dry Cargo Shipped (Q_{dc}) - in million metric tons

$$Q_{dc} = 4.511 \; N^{1.079}$$

VII. Gross Tonnage of Dry Cargo Ships Supplied - in million gross tons

$$GRT_{dc} = 226.2e^{.048t} \; FR_{t-2,dc}^{.125} \; FR_{t-4,dc}^{.052}$$

VIII. Freight Rates for Dry Cargo ($FR_{t,dc}$) - index

$$FR_{t,dc} = .0931e^{-.115t} \; Q_{dc}^{2.296} \; GRT_{dc}^{-.947}$$

Additionally

P_{oil} = Weighted World Oil Price, Constant 1975 Dollars - in \$/barrel

N = Index of World Industrial Production, 1963 = 100

t = Year, 1950 = 1

Figure 2.2 System of Equations Used to Make Global Forecasts

2.2.3 The Results - Global Forecasts

The data used to make the global forecasts was from 1950-1973 in most, but not all, cases. Quantity of oil shipped, quantity of dry cargo shipped, gross tonnage of oil tankers and dry cargo ships, and active tonnage of oil tankers are found in OECD Maritime Transport, 1973 [28]; the freight rates for tankers and dry cargo are from the Norwegian Shipping News [6]; consumption of oil is from the United Nations, World Energy Supplies, Series J [7]; the index of world industrial production is from the United Nations, Growth of World Industry [8]; and the price per barrel of oil is found in the United Nations, Monthly Bulletin of Statistics [9] and weighted by the relative amounts of production and deflated by the U.S. wholesale price index as found in the U.S. Department of Commerce, Statistical Abstract of the United States [10].

Using this data base, the coefficients of the system were estimated and presented above in Figure 2.2, system of Equations Used to Make Global Forecasts. In general, the fits were good with R^2 above .90 in all cases except for freight rates which exhibited an oscillatory behavior and yielded R^2's of about .50. A polynomial or sinusoidal function would have yielded a better fit but would not have been useful for such long extrapolations as the 1985-2000 time period. The t values were low in some cases (only significant above the .80 level) where a causal explanatory variable was desirable, as in the case of the price per barrel of oil.

The forecast results are presented in Figure 2.3, Global Forecasts from Econometric Model. The following results were found:

- The quantity of oil shipped will continue to grow, but at a slightly slower rate (10.3% down to 9.4% per annum)
- The growth of the tanker freight rate index will continue, but at a slower rate (2.5% down to 2.0% per annum)
- The growth of gross tanker tonnage will continue at about the same rate (8.3%), although this will mean fewer ships since the size of tankers is increasing
- The quantity of dry cargo shipped will grow at a faster rate (6.2% up to 7.0% per annum)
- The decrease in the dry cargo freight rate index will continue, but at a slower rate (-1..% down to -0.4%)
- The growth of gross dry cargo ship tonnage will continue, but at a higher rate (4.0% up to 4.9% per annum).

These forecasts were based on a number of assumptions. It was assumed that world industrial activity would continue to increase at about the same rate as in the period 1950-1973. It was assumed that the price per barrel of oil would jump from $3.42 to $11.00 per barrel in 1974 and would continue to grow at the rate of the 1950-1973 period, i.e., slightly less than 1% increase per annum.

2.2.4 Densities of Global Traffic on Major World Routes

The distribution of ships globally is difficult to estimate. A limited number of such comprehensive data sources which would make such estimates possible are available. The

	Year	C_{oil}	Q_{oil}	GRT_{oil}	$AGRT_{oil}$	FR_{oil}	Q_{dc}	GRT_{dc}	FR_{dc}	N	P_{oil}
	1985	6791	4034	2800	2536	54.28	2913	2734	74.44	401	12.09
	1986	7308	4413	3040	2759	54.94	3118	2866	74.18	427	12.21
	1987	7864	4827	3300	3002	55.60	3338	3005	73.91	455	12.32
	1988	8462	5281	3583	3265	56.28	3573	3151	73.64	484	12.44
	1989	9106	5776	3891	3552	56.96	3824	3303	73.37	516	12.56
	1990	9800	6319	4224	3865	57.66	4093	3463	73.11	549	12.68
	1991	10545	6912	4586	4204	58.36	4381	3631	72.84	585	12.80
	1992	11348	7561	4979	4574	59.07	4689	3807	72.58	623	12.92
	1993	12212	8271	5406	4976	59.78	5019	3991	72.31	664	13.04
	1994	13141	9047	5869	5413	60.51	5372	4184	72.05	707	13.17
	1995	14141	9897	6372	5889	61.25	5750	4387	71.79	753	13.29
	1996	15218	10826	6919	6407	61.99	6154	4599	71.53	802	13.42
	1997	16376	11842	7512	6970	62.74	6587	4822	71.27	854	13.55
	1998	17622	12954	8156	7582	63.51	7051	5056	71.01	910	13.68
	1999	18963	14170	8855	8249	64.28	7547	5300	70.75	969	13.81
	2000	20407	15500	9613	8973	65.06	8077	5557	70.50	1032	13.94
Annual Growth Rate Estimated, 1975-2000		7.6%	9.4%	8.3%	8.7%	2.0%	7.0%	4.9%	-0.4%		
Previous Growth Rate		7.7%	10.3%	8.2%	8.7%	2.5%	6.2%	4.0%	-1.1%		

Figure 2.3 Global Forecasts from Econometric Model

most comprehensive source of operating information on ships are Lloyd's Register of Shipping and Lloyd's Register of Shipping Statistical Tables. The U.S. Maritime Administration publishes A Statistical Analysis of the World Fleet [25] each year based on Lloyd's data. However, only about half the world's fleet of 21,000 will be at sea at any one time. The U.S. Coast Guard also operates an Automated Mutual-Assistance Vehicle Rescue System (AMVER) as an international program by which vessels may indicate their sail plans. This computer-based system enables participants to receive emergency assistance from one another. While the number of participants may vary considerably, the 2,097 average of ships (daily average of vessels on daily plot) which participated in October 1974 is not unusal.

A number of maritime research groups have conducted studies of the densities of the world fleet on the various trade routes. These organizations include: Ocean Routes, Inc., of Palo Alto, California; Ocean Data Systems, Inc.; and Automated Marine International. The most comprehensive analysis of world fleet densities by route that has been done recently is by Automated Marine International [16, Volume I].

The Automated Marine International study of densities was done in three different ways to provide a consistency check. The first method was to update a World Meteorological Organization (WMO) study of densities done in 1964. The second method was the use of Lloyd's List, a daily publication with arrival and departure information for 3,000 to 5,000 ships, to compile a density map. The third method was the use of AMVER data as a sample to project the overall densities. The results indicated fairly similar estimates for the WMO and Lloyd's based studies, but the AMVER data lacked sufficient representativeness to yield reliable results. In addition to making estimates for 1969, forecasts of densities were made for 1972 and 1975 and 1980. The results are summarized in Figure 2.4, Ship Population Trends by Ocean, 1969 to 1980. An illustration of the density map for the 1980 forecast is given in Figure 2.5, 1980 Projected Overall Worldwide Merchant Ship Distribution.

The principal facts to note in the estimates are the equal dominance of Atlantic and Pacific routes. The AMI forecast for 1980 indicated only two major shifts. These were the increasing trade flows to and from Japan, based on Japan's exceptional economic growth, and the shift of the world's fishing fleet away from the traditional fisheries (as they reach or exceed their maximum sustainable yield) to new waters in the Indian Ocean and elsewhere. However, since the Automated Marine International study was done, Japan's economic growth has slowed. In addition, this study does not deal with the world fishing fleet. Therefore, it will be assumed that the Atlantic and Pacific routes will continue to contain the bulk of world shipping for the generalization made in Section 3.4.

VESSEL SERVICE CATEGORY	1969 (20,973 total)				1972 (24,575 total)			
	ATL.	PAC.	IND.	MISC.	ATL.	PAC.	IND.	MISC.
TANKERS	2,680	457	741	759(M)	2,478	791	1,134	346(M)
CARGO VESSELS	2,251	1,044	1,138	438	1,957	927	1,018	483
ORE & BULK	609	673	82	110(S)	783	990	143	180(S)
PASSENGER	104	30	13	12	94	27	12	11(M)
COMBINATIONS	100	54	57	28	93	43	46	25
OTHER	124	58	62	26	109	51	54	30
SUBTOTAL	5,868	2,316	2,093	1,373	5,514	2,829	2,407	1,075
FISHING	3,629	5,115	372	197(M)	4,346	6,185	1,987	232(M)
TOTAL	9,507	7,431	2,465	1,570	9,860	9,014	4,394	1,307

S = St. Lawrence
M = Mediterranean

Source: Automated Marine International [16, Volume I, p. 156].

Figure 2.4 Ship Population Trends by Ocean, 1969 to 1980

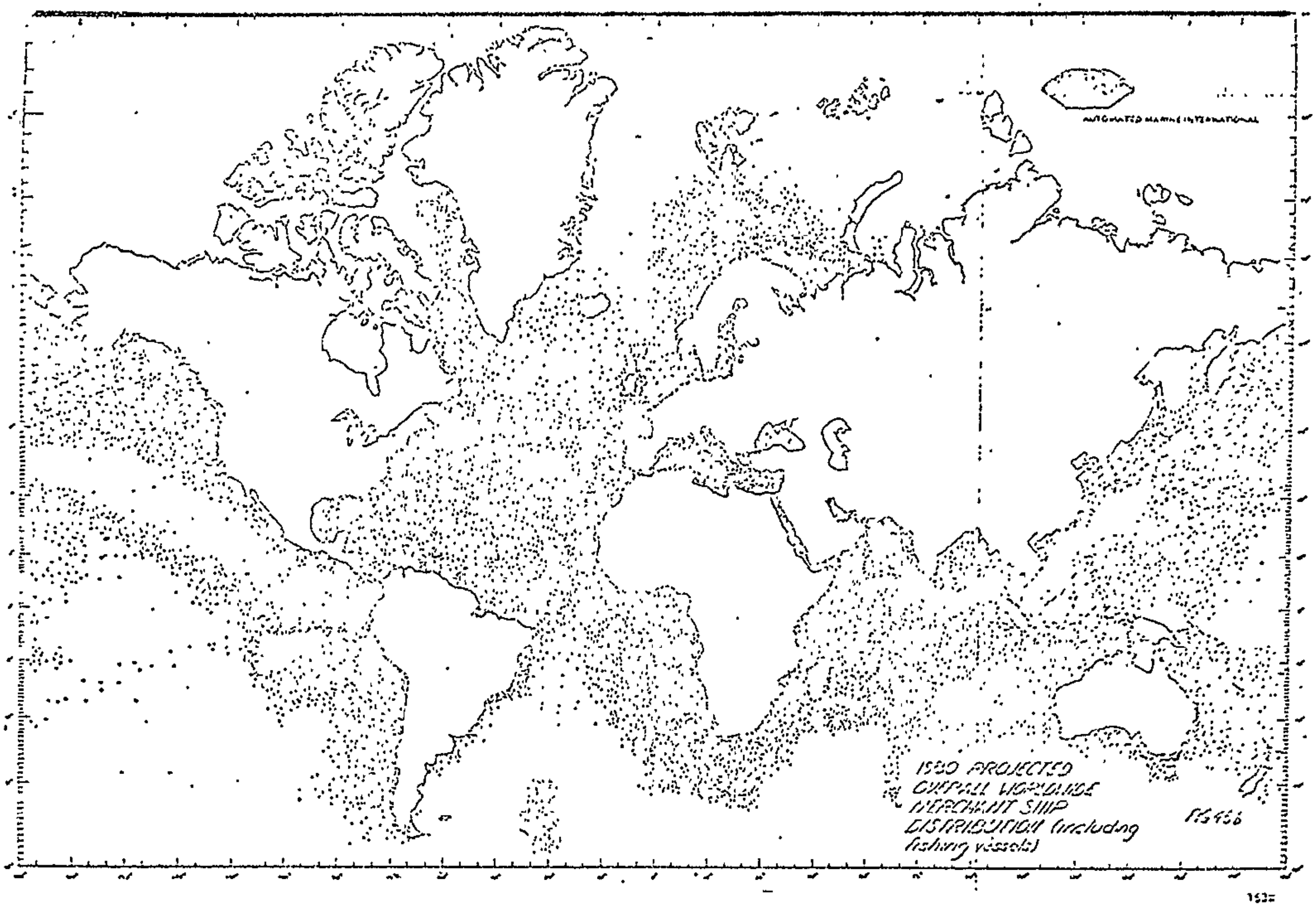
VESSEL SERVICE CATEGORY	1975* (26,313 total)				1980 (29,213 total)			
	ATL.	PAC.	IND.	MISC.	ATL.	PAC.	IND.	MISC.
TANKERS	2,440	951	1,227	435	2,377	1,218	1,382	582(M)
CARGO VESSELS	1,975	963	1,036	481	1,999	1,022	1,068	477
ORE & BULK	953	1,356	150	171	1,237	1,965	161	156(S)
PASSENGER	94	27	12	11(M)	98	28	13	11(M)
COMBINATIONS	95	45	48	24	97	49	50	23
OTHER	110	52	55	30	113	56	58	27
SUBTOTAL	5,667	3,394	2,528	1,152	5,921	4,338	2,732	1,276
FISHING	4,669	6,285	2,383	235	5,209	6,452	3,044	241(M)
TOTAL	10,336	9,679	4,911	1,387	11,130	10,790	5,776	1,517

* STRAIGHT LINE INTERPOLATION BETWEEN 1972 & 1980 FORECASTS

S = St. Lawrence
M = Mediterranean

Source: Automated Marine International [16, Volume I, p. 156].

Figure 2.4 Ship Population Trends by Ocean, 1969 to 1980 (Continued)



Source: Automated Marine International [16, Volume I, p. 153]

Figure 2.5 1980 Projected Overall Worldwide Merchant Ship Distribution

2.3 Weather Routing Procedures and Potential Benefits

Attempts by ships to avoid adverse weather have already been systematized. The system is referred to variously as optimum track ship routing (OTSR), optimum ship routing (OSR), or, simply, ship routing or weather routing. Data from SEASAT which is to be used for ship routing will probably be fed into the existing weather routing set of systems. This was one of the reasons for taking a close look at weather routing. A second important reason for scrutinizing the present weather routing system was that it was one way to quantify the potential benefits of SEASAT in this area. By examination of the impact of the present weather routing systems on weather-related casualty costs and operating expense losses, together with an assessment of the capability of SEASAT to extend these savings, it was possible to measure the economic effect in the marine insurance area of SEASAT-type data.

2.3.1 The Present Weather Routing Systems

There is no single weather routing system today. Rather, there are a number of commercial services such as Louis Allen, Washington, D.C.; Bendix Commercial Service Corporation, South Hackensack, New Jersey; Ocean Routes, Inc., Palo Alto, California; and the Navy's Fleet Numerical Weather Central (FNWC), Norfolk, Virginia, and Monterey, California. In addition, there are weather routing services operated by foreign individuals and governments.

The charge per ocean crossing for these routing services may run from $95 to $300, but is generally in the $200 to $250 range. The charge may be for simply recommending the entire route in one analysis before the crossing begins, or it may involve a more complete service. In its most thorough form, the weather routing might involve a discussion with the captain before departure to obtain such information as the cargo to be carried, will any of it be stored on deck, or is there any special reason that a speedy crossing is necessary. A recommended route will then be selected based on the information gathered from the captain, from weather forecasts, from information about the ship's rated speed and ability to handle heavy seas, etc.

Once the voyage is begun, the weather router may contact the ship with revised information or suggestions as to the route as often as twice a day. The FNWC runs its forecasting program and ship routing program twice a day, and Navy ships often have a radio operator on duty continuously. However, for commercial vessels, route recommendations are restricted to usually one contact per day since most commercial vessels have one radio operator who will be on duty nine hours per day (usually in three-hour daylight shifts with one-hour, in-between shifts). When the voyage is completed, the routing service may also involve a post-voyage consultation and analysis. The ship's log book may be examined in conjunction with a record of the router's recommendation to ascertain the cause of a slow crossing time or failure to avoid a heavy storm or the reason for the departure from the recommended route.

The above description pertains to a complete weather routing service. Often, contact is made only every few days, whenever a major change in weather conditions on the route takes place, and there may not be a post-voyage analysis.

Weather routing became available in the early 1950's, but the expansion of the weather routing services did not occur until the mid-1960's. Presently, on a given day, Ocean Routes; Bendix; Louis Allen, Inc.; FNWC Monterey; and FNWC Norfolk may handle 850 ships among them. These numbers may vary considerably. For example, Ocean Routes may handle 1,000 ships on a given day and FNWC Monterey may handle more than 200 ships during a major military supply effort. Since 11,000 to 12,000 of the world fleet of approximately 21,000 may be on the ocean on a given day, the American commercial and government weather routing services will be guiding approximately 7% of all ships on the oceans on any such day.

2.3.2 The FNWC Monterey Weather Routing Procedure

The weather routing services vary considerably in their technical approach to ship routing. In general, Ocean Routes and FNWC Monterey follow an automated approach, while all others are manual. A detailed discussion of the FNWC Monterey operation is given here.

The basic input data come from the local 0800 report of ships at sea (that is, 0800 in the ship's time, not FNWC time. Since FNWC deal mostly with the Pacific, this will cover eight time zones). The 0800 report provides a daylight reading that is desirable especially to yield wave conditions. The 0800 report usually includes:

1. Position
2. Course and speed
3. Wind
4. Seas

Another data input is the more detailed synoptic weather report provided by some ships. The synoptic report usually includes:

1. Latitude and longitude
2. Data time group in Greenwich Mean Time
3. Cloud cover
4. Wind - direction and force
5. Visibility
6. Temperature
7. Present weather - fog, rain
8. Last weather (exactly 3 hours ago)
9. Barometric pressure
10. Type and height of clouds
11. Course and speed
12. Sea water temperature
13. Sea direction and height
14. Swell direction and height

The FNWC Monterey deals with a ship population which may be 50% Navy fleet ships and 50% Military Sealift Command (MSC). MSCs are commercial ships on lease to the government. About 95% of these ships send in the 0800 report. About 20-30% of the ships send in synoptic reports every six hours ideally. Some ships, especially MSCs, have only one radio operator and they send only one synoptic report in his on-duty hours. Fleet ships are more apt to have a complete reporting schedule.

The measurements by ships at sea are usually done by sight and rough estimation rather than by scientific instruments. The procedures for making these rough estimates are described in Bowditch, American Practical Navigation, H. O. Publication, No. 9, p. 1060.

Fleet ships send reports directly to Naval Communications, while MSC vessels, which are on a commercial broadcast frequency, transmit a commercial message, which is then fed into Naval Communications. FNWC is hooked up to all Naval Communications by switching techniques. The transmissions come out as typed messages at FNWC; they are written by hand onto coding sheets, keypunched, and fed into an update program. However, in a matter of months, FNWC expects to eliminate the transcription to cards and go directly onto tape with the ship reports.

Weather information is collected from other sources besides the ships at sea. For example, the National Weather

Service products collected include:

- Teletype - raw data
  - analyses
  - forecasts
- Facsimile - analyses
  - forecasts
  - satellite photos.

National Weather Service weather products are used subjectively at present by FNWC; i.e., they are not direct inputs to FNWC programs for forecasting and ship routing. Some of the commercial services rely heavily on NWS products. For example, Ocean Routes may use, very roughly, one-third each of inputs from ships, FNWC, and NWS in making their routing recommendations. In addition to the NWS, FNWC collects weather products from a variety of services such as the U.S. Air Force and foreign government weather services. There is considerable exchange of whatever information is available among weather agencies and ship routers.

After the data base is updated, a forecast is made. The forecast program is run twice a day, beginning at 0000 and 1200, local time. It takes 4-1/2 to 6 hours to run. Of this time, three hours may be spent in internal data transformation and 1-1/2 hours may be spent making the actual forecast. The resulting forecasts are used for a great variety of purposes, of which ship routing is only one. The outputs of the forecasting program go onto magnetic tape and become direct input to the ship routing computer program. Previously prepared computer cards with ship information such as identification, ship type, destination, etc., are also an input at this time to the ship routing program. There are a great number of mathematical models which use variational calculus to select the optimum tract (minimize time for ocean crossing subject to a constraint on the wave height or wind conditions to be encountered). A list of these programs has been compiled by Bendix Commercial Service Corporation and is presented in the accompanying Figure 2.6, Optimum Track Ship Routing Programs and Related Weather Forecasting Programs. For a discussion of these techniques, see W. Marks et. al. [17].

Once the recommended route is determined by the computer program, a manual check is made to see if any change in the previously recommended route is called for. The results will then be transmitted to the ships at sea by radio at the earliest convenient time. This may be almost immediately if some unusual or drastic action is called for and if the radio operator can be contacted. More likely it will be several hours, possibly as many as 12 hours, before the results are transmitted to ships. For a more detailed description of the forecasting program and the ship routing program in use at FNWC Monterey, see William M. Clune [18].

Bunting, D.C., 1966, Wave Hindcast Project-North Atlantic Ocean, TR-183, U.S. Naval Oceanographic Office, Washington, D.C., 42 pp.

Moskowitz, L. I., 1967, Evaluation of Spectral Wave Hindcasts Using the Automated Wave Prediction Program of the Naval Oceanographic Office, IR No. 67-78, U.S. Naval Oceanographic Office, Washington, D.C., 32 pp.

Thomasell, A. Jr., and J. G. Welsh, 1963, Studies of the Specification of Surface Winds over the Ocean, 7049-88, The Travelers Research Center, Inc., Hartford, Connecticut, 47 pp.

Baer, L., 1962, An Experiment in Numerical Forecasting of Deep Water Ocean Waves, LMSC-801296, Lockheed Missile and Space Company, Sunnyvale, California, 142 pp.

Inoue, T., 1967, On the Growth of the Spectrum of a Wind Generated Sea According to a Modified Miles-Phillips Mechanism and its Application to Wave Forecasting, TR-67-5, School of Engineering and Science, New York University, New York, New York, 81 pp.

Pierson, W. J. Jr., L. J. Tick, and L. Baer, 1966, Computer Based Procedures for Preparing Global Wave Forecasts and Wind Field Analysis Capable of Using Wave Data Obtained by a Spacecraft, in Volume II, 6th Naval Hydrodynamics Symposium, September 28 - October 4, 1966, Washington, D.C., 42 pp.

Barnett, T. P., 1968, On the Generation, Dissipation, and Prediction of Ocean Wind Waves, Journal of Geophysical Research, 73(2), pp. 513-529.

Michel, W. H., 1968, Sea Spectra Simplified, Marine Technology, pp. 17-30.

, 1967, Ship Performance Characteristics-Speed vs. Sea State, Tech. Memo. No. 1059-3, Oceanics Inc., Plainview, New York, 59 pp.

Bleick, W. E. and F. D. Faulkner, 1964, Minimal-Time Ship Routing, Research Paper No. 46, U.S. Naval Postgraduates School, Monterey, California, 25 pp.

Bleick, W. E., F. D. Faulkner, and G. J. Haltiner, 1967, Single Ship Routing, Tech. Rept./Res. Pap. No., 73, U.S. Naval Postgraduate School, Monterey, California, 48 pp.

Haltiner, G. J., W. E. Bleick, and F. D. Faulkner, 1967, Use of Long-Range Weather Forecasts in Ship Routing, Tech. Rept./Res. Pap. No. 78, U.S. Naval Postgraduate School, Monterey, California, 40 pp.

Note: List compiled by Bendix Commercial Service Corporation.

Figure 2.6 Optimum Track Ship Routing Programs and Related Weather Forecasting Programs

In summary, the throughput time for the weather routing at FNWC Monterey involves:

1. Data collection - continuous, eclectic
2. Data processing - 1/2 to 1 hours
3. Forecasting program - 4-1/2 to 6 hours
4. Ship routing program - 1/2 to 1-1/2 hours
5. Distribution of results - 0 to 12 hours

Total throughput time - 5-1/2 to 20-1/2 hours

2.3.3 Present Weather Forecast Accuracy

Improvements in weather routing procedures will come from a number of developments. These include:

- Better forecasting:

  from better and greater quantities of data, and from advances in the mathematics of forecasting models

  from management improvements which yield shorter throughput times

- Better ships:

  design improvements which provide greater strength and/or greater speed which permits ships to outrun or skirt storms

Focusing on better forecasting, two areas of general improvement are possible in regard to accuracy.

- Shortened throughput time due to better management practices
- System improvements which include advances in forecasting science, more data, better quality of data.

The first type of improvement essentially involves providing more up-to-date forecasts. Since all current forecasting indicates a gradual deterioration until the forecasts are no better than a random forecast, the accuracy is improved by shifting the forecast accuracy function to the right, as illustrated in Figure 2.7, Improvement in the Weather Forecasting System.

The second type of improvement, system improvements, tends to shift the forecasting accuracy function straight up, illustrated in Figure 2.7, Improvement in the Weather Forecasting System.

There is no generally agreed upon measure of accuracy of forecast in common use. In the case of ship routing, the most important measure is sea-state, which more specifically is measured by wave height. Other commonly used measures of sea-state include wind velocity, Beaufort wind scale, and sea-state number. The interrelations of these measures is presented in Figure 2.8, Descriptors of Sea-State, from Rhodes and Chadwick, [11, p. 2]. An appropriate measure of accuracy might then be the percentage of time the forecast wave height was within some specified error limit from the observed wave height. This would be on the horizontal axis in Figure 2.7.

The National Weather Service forecasts are supported by a verification program. A summary of the forecast verification for April 1972 to March 1973 is given in Sadowski [36].

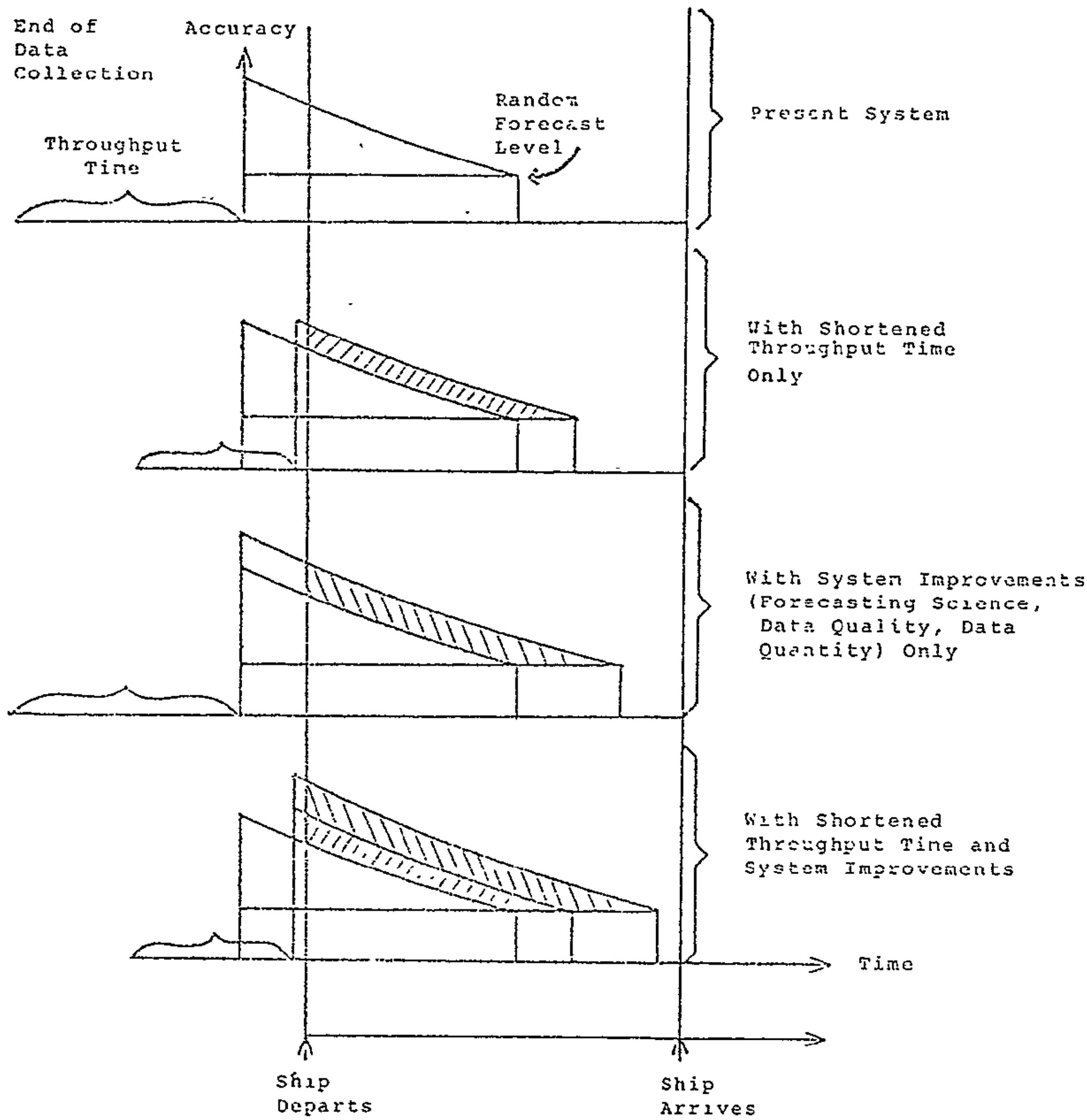


Figure 2.7 Improvement in the Weather Forecasting System

Descriptor											
Mean Wind Velocity (knots)	2	5	9	13	19	24	30	37	44	52	60
Beaufort Wind Scale	1	2	3	4	5	6	7	8	9	10	11
Sea-State Number	1 Rippled	2 Smooth	3 Slight	4 Moderate	5 Rough	6 Very Rough	7 High	8 Very High	9 Precipitous		
Significant Wave Height (feet)	1	2	4	6	10	15	20	30	40	60	

Sources: Rhodes and Chadwick [11].

Figure 2.8 Descriptors of Sea-State

However, these verification results are for land areas. The office within NOAA that makes wave height forecasts is Ocean Services Division. Their measure of accuracy is the mean absolute error in feet as defined in Sadowski [36]. Verification was accomplished until recently by comparison of forecasts with observations from Ocean Station Vessels (U.S. Coast Guard ships at sea) which, with one exception, are no longer available. For July-August in 1969, for example, on the North Atlantic the following results were realized:

Forecast horizon (hours)	12	24	36	48
Forecast accuracy (mean absolute error in feet)	2.5	2.5	2.7	2.9

The observed mean height of waves in this period was 4.4 feet. For January-February on the North Atlantic the mean wave height was 7.4 feet with a standard deviation of 6.0 feet, while the mean absolute error of forecast was 4.0 feet for the 36-hour forecast.

More recently, the Weather Service Forecasting Office has been conducting verification of the Ocean Services Division wave height forecasts. The 1974 summary is based on 10 circular areas in the North Atlantic of approximately 240 nautical miles in diameter. The circular areas are found between 32° north to 60° north latitude and between the east coast of the U.S. and 35° west longitude. The verification indicates accuracy similar to the earlier study. For example, the 36 hour, July-August mean absolute error of forecast was again 2.7 feet.

The earlier ocean condition forecast verification activities of the National Weather Service are discussed in Pore and Perrotti, "Results of the Techniques Development Laboratory, Automated Wind-Wave Forecasts for the Period of September 1968 Through August 1970," [12] and Pore and Richardson, "Weather Service Program in Objective Wind-Wave and Swell Forecasting," [19].

The general level of present weather forecasting accuracy has been summarized in American Meteorological Society, "Policy Statement of the American Meteorological Society on Weather Forecasting, as adopted by the Council on October 20, 1972," Bulletin of the American Meteorological Society, 54(1), January 1973, pp. 47-48. A relevant portion of this statement follows:

> Weather forecasts prepared by professionally-trained personnel presently achieve the following levels of skill, on the average:
>
> For periods up to 48 hours, weather forecasts of considerable skill and utility are attained. Detailed forecasts of weather and its changes can be made for the first 36 hours. Probability estimates markedly increase the information content of such forecasts, especially with regard to precipitation occurrence. In this period, skill is a maximum in predicting the motion and general effects of weather systems having dimensions of five-hundred miles or more. However, small-scale features imbedded in these systems cause hour-to-hour variations in weather which are difficult to predict, especially for local areas with irregular

topography. Also, the exact location of certain highly significant weather phenomena, such as severe thunderstorms and tornadoes, cannot be forecast accurately with any degree of skill beyond a few hours, although the general area of severe storm activity may be predicted up to 24 hours in advance. Accurate forecasts for infrequent events such as heavy snow, sleet and damaging winds are usually limited to periods not exceeding 24 hours.

For periods up to 5 days, daily temperature forecasts of moderate skill and usefulness are possible. Precipitation forecasts to 3 days, at an equivalent level of skill, can be made, but the skill drops to marginal levels on the fourth and fifth days.

For periods of more than 5 days, average temperature conditions for periods from a week up to a month or season can be predicted with some slight skill. Day-to-day or week-to-week forecasts within this time range have not demonstrated skill. There is some skill in prediction of total precipitation amounts for periods of 5 to 7 days in advance; skill for longer periods is marginal.

Recent theoretical work on atmospheric predictability indicates that the intrinsic properties of the atmosphere, together with the impossibility of observing every detail of atmospheric behavior, impose an upper limit for the prediction of day-to-day weather changes. This period is believed to be about one to two weeks, depending on the criteria used to define a useful forecast. Present day forecasting accuracy, as cited above, falls short of the theoretical limit. There are also limits to the extent of time for which average quantities such as weekly or monthly mean temperatures can be forecast, but theoretical estimates of these limits are not available as yet.

Since the general level of forecast accuracy falls short of theoretical limits, it may be assumed that at least the same is true for ocean condition forecasts where there is a greater paucity of input data for the forecasting process.

2.3.4 Future Weather Forecasting Systems

In order to assess the benefits from SEASAT ocean condition data for the 1985-2000 time period, it was necessary to survey the types of forecasting systems which might be operational, determine the improvements in forecasting possible with these systems, compare SEASAT with the other systems, and determine the probability that the improved forecasting systems would be used. This involved the gathering of qualitative inputs from a number of individuals by interview. These included George Hammond of Fleet Numerical Weather Central (FNWC) Monterey, George Francis of FNWC Norfolk, Robert Raguso of Bendix Commercial Services, William Dupin of Ocean Routes, ship captains from shipping companies operating out of New York and New Orleans, Kikuro Miyakoda of the Geophysical Fluid Dynamics Laboratory, William Shenk of NASA, and Susan Hellie and Art Pore of the National Weather Service.

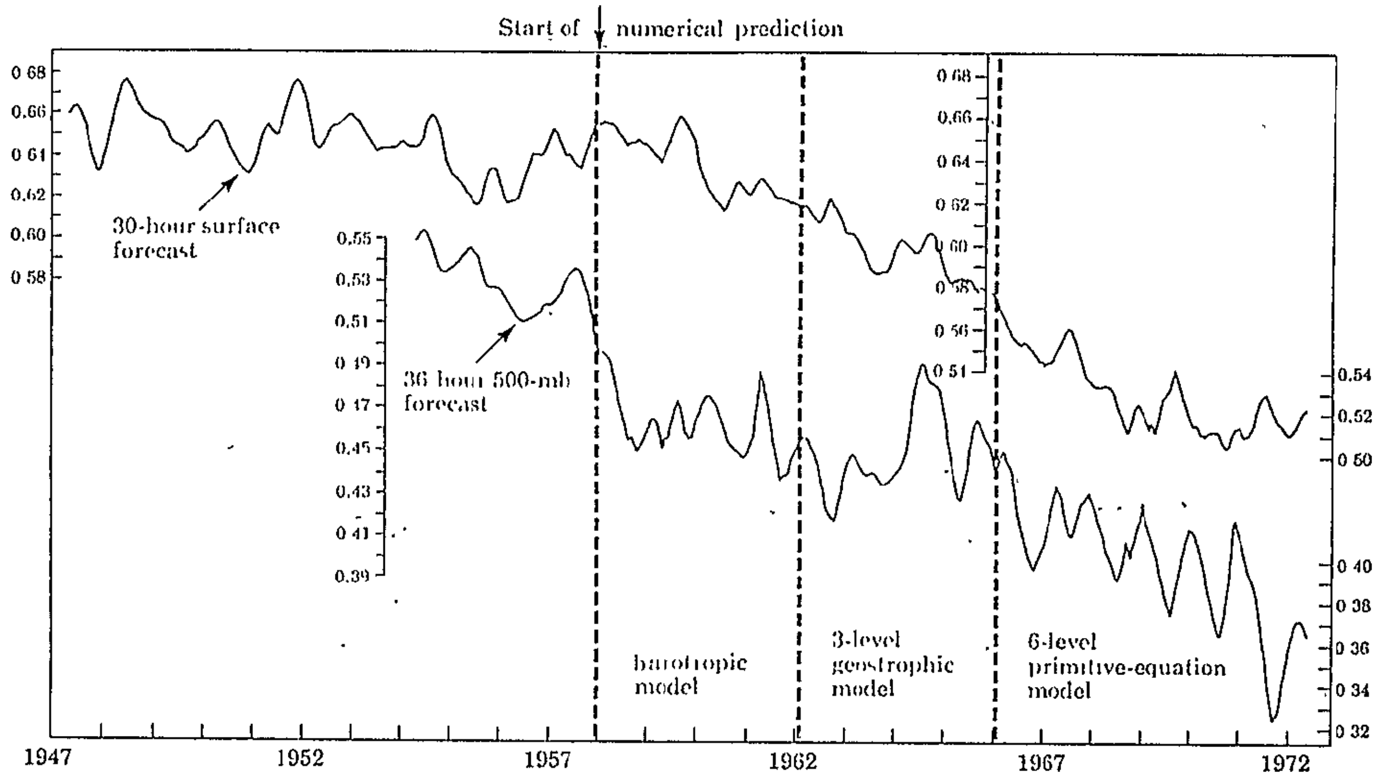
In addition to Satellites such as SEASAT there are a number of other data-gathering methods which could be used in oceanographics. These include:

- Data balloons
- Data buoy sensors
- Commercial aircraft
- Over-the-horizon sea-state radar
- Improved shipboard techniques.

The general impact of these data-gathering techniques is, of course, better forecasting due to increased observations. In a comparison of buoys, satellites, shipboard techniques, and radar, Rhodes and Chadwick [11, p. 50] found system costs for all techniques to be about equal for similar coverage but that "satellites have the special advantage of routinely gathering data from all oceans of the world, not just the waters near North America." Since complete ocean coverage is mandatory for a full ocean routing service, the satellite system has a special advantage in this regard over all other potential systems.

Increased observations are not the only method to better forecasting in the future. Computer technology can provide finer grid resolution over oceans, which is especially important if the vast quantity of SEASAT data is to be fully utilized. Also, meteorological R&D efforts can lead to better modeling in the form of more realistic initialization of system forecasting equations and more realistic equations. As more data and better mathematical models become available, forecasting skill scores of Weather Service forecasters improved from 1950 to the present (See Figure 2.9 from Miyakoda [20, p. 568]).

In an interview with Miyakoda, he stressed the need for better ocean temperature information if the present skill-forecast horizon of 5 days is to be extended to, say, 8 or 10 days. He believes that, with the proper data and models, some



Source: Miyakoda [20, p. 568].

Note: In the S-1 skill-score record of the NMC operational forecasts, the upper curve is for the 30-hour surface prognostic, and the lower curve is for the 36-hour 500-mb prognostic. Both curves are obtained by first averaging the scores for each day over one month and then smoothing the resulting values over 5 months with a weighting function of 1:2:4:2:1. Data courtesy of NMC.

Figure 2.9 Skill-Score Record of the NMC Operational Forecasts forecasting skill can be demonstrated for time periods of up to one month. In the SEASAT system, sea surface temperature will be obtained by a microwave radiometer. The advantage which SEASAT will yield over the systems of the future in the area of ship routing, then, depends partly on this surface temperature sensing capability and partly on its extensive and more frequent coverage.

The 1970 statement of the American Meteorological Society in the preceding section indicated that the limits of weather forecasting skill have not been reached. Interviews with the meteorologists mentioned above reaffirmed this belief today. The ship routers interviewed stressed the fact that they were anxious to receive better weather forecasts and felt they could provide better routing service as a result. Three of the ship captains interviewed expressed skepticism about the ship routing services, while four claimed they had experienced some success with it. All captains have routing services available to them. Some captains also feel that routing suggestions, which sometimes come from the home office rather than directly from the ship router, infringe on their freedom of movement. However, it was generally agreed that, if historical experience shows routed ships experiencing less delays and damage than unrouted ships, captains will be more likely to seek and follow routing suggestions, and ship owners will be more insistent that they do so.

The quantification which resulted from these interviews and studies is given in the dry cargo study under each of the appropriate topics.

2.4 Marine Insurance Practices of Shipowners

If SEASAT can be used to route ships around adverse weather resulting in benefits in reduced damage costs and operating costs, the question arises: to whom do the benefits accrue? No attempt was made to answer this question in the preliminary economic assessment performed in 1974, SEASAT Economic Assessment [21]. The answer to this question depends on the competitiveness of the marine insurance industry, the shipping industry, the distributive and retail industry, and the original manufacturing industry. Economic theory can show that, if each of these were a perfectly competitive industry, the full cost reduction would be passed on to the ultimate consumers. For goods on U.S. trade routes, this would mean imported goods would be cheaper for the American consumer, U.S. exports would become more competitive in foreign markets, and foreign trade in general would assume an incrementally greater role in the U.S. economy.

However, the industries involved are not perfectly competitive, and only a portion of any true savings will be passed on to the consumers. An attempt will not be made to trace out the ultimate savings realized by consumers. Rather, the more modest goal of measuring the initial distribution of the benefit will be quantified in this section.

2.4.1 The Incidence of Costs and Distribution of Benefits

The previous study, SEASAT Economic Assessment [21], contained a brief outline of the marine insurance industry and insurance rate setting practices in Section 5.2, Maritime Insurance Rate Economics. The principal point of this analysis was the fact that marine insurance rates are set on the basis of experience rather than by expectations or by general class. Essentially, this means that rates cannot be reduced immediately for a shipowner when he installs some new safety feature (such as better ship routing) but only after experience indicates that the new feature leads to lower claims. Thus, the initial benefits will accrue to the marine insurance company to the extent that the owner relies on premium insurance.

Many shipowners rely on self-insurance (retain the risk themselves) to meet casualties and other claims which arise. In order to assess the distribution of the initial benefit, it was necessary to get some measure of the ratio of retained risk to premium insured risk. No such data were generally available, and preliminary interviews revealed two problems: a reluctance of shipping companies to reveal their loss statistics and a great difference of opinion on what would be the ratio of retained risk to premium insured risk. Therefore, a mail survey was undertaken to estimate this ratio.

Mail surveys were sent to 17 major U.S. shipping companies and oil companies with tanker fleets (5 major U.S. shipping or oil companies and 2 foreign shipping companies indicated in a preliminary telephone survey that they would not be willing to complete the mail questionnaire). The companies were guaranteed anonymity, and only the percentage distribution of premium insurance and self-insurance was requested. In response to this survey, 9 questionnaires were received.

The questionnaires were distinguished by type of vessel:

- Container Ships Exclusively
- Dry Bulk Ships
- General Cargo Ships and Combination Container/ General Cargo Ships
- Tankers and Other Liquid Bulk Ships.

Figures were requested for the years 1970 through 1974. An example of each of the questionnaires is presented in Figure 2.10, Shipowner Questionnaire. The results of the survey are presented in Figure 2.11, Summary of Survey Results.

Since the sample size is small and possibly not representative, it should be assumed that great uncertainty surrounds these figures. The sample representativeness is questionable because only large shipping companies were approached, response was voluntary (shipping companies with large recent losses might be more reluctant to respond), there were only 9 companies which responded, and only U.S.

shipping companies were among the respondees (the U.S. fleet only carries 7% of all trade on U.S. trade routes).

The number in Figure 2.11, Summary of Survey Results, are only relative numbers in regard to coverage. The next section presents some indication of the overall marine insurance market.

2.4.2 The Market

The composition of the marine insurance market is difficult to determine because it is an international market, casualty statistics are poor or nonexistent, the U.S. fleet is only a small part of the world merchant fleet, and marine insurance is only a small part of the U.S. insurance industry (less than 2% of all premiums). For 1973, Best's Aggregates and Averages [22, p. 34] has for Stock Company underwritings:

5.0% Ocean Marine

9.8% Inland Marine

85.2% All Other.

And for the years 1971-1973 the total U.S. marine insurance market according to the Insurance Advocate was:

Earned Premiums For the Years
(millions)

	1971	1972	1973
Stock Company	$413	$467	$549
Mutual Company	38	48	46
Reinsurers and Others	20	31	38
Total Ocean Marine	$471	$546	$633

Type Vessel: Container Ships Exclusively			
	Percent of All Casualty Costs* Covered By		
Casualty Category	Marine Insurance	Self Insurance	Number of Casualties Involved
Hull 1970			
1971			
1972			
1973			
1974			
P & I 1970			
1971			
1972			
1973			
1974			

* Casualty Costs - for the year in which the casualty occurred, rather than when payment was made.

Figure 2.10 Shipowner Questionnaire

Type Vessel: Dry Bulk Ships				
Casualty Category		Percent of All Casualty Costs* Covered By		Number of Casualties Involved
		Marine Insurance	Self Insurance	
Hull	1970			
	1971			
	1972			
	1973			
	1974			
P & I	1970			
	1971			
	1972			
	1973			
	1974			

* Casualty Costs - for the year in which the casualty occurred, rather than when payment was made.

Figure 2.10 Shipowner Questionnarie (Continued)

Type Vessel: General Cargo Ships and Combination Container/General Cargo Ships			
Casualty Category	Percent of All Casualty Costs* Covered By		Number of Casualties Involved
	Marine Insurance	Self Insurance	
Hull 1970			
1971			
1972			
1973			
1974			
P & I 1970			
1971			
1972			
1973			
1974			

* Casualty Costs - for the year in which the casualty occurred, rather than when payment was made.

Figure 2.10 Shipowner Questionnaire (Continued)

Type Vessel: Oil Tankers and Other Liquid Bulk Ships				
Casualty Category		Percent of All Casualty Costs* Covered By		Number of Casualties Involved
		Marine Insurance	Self Insurance	
Hull	1970			
	1971			
	1972			
	1973			
	1974			
P & I	1970			
	1971			
	1972			
	1973			
	1974			

* Casualty Costs - for the year in which the casualty occurred, rather than when payment was made.

Figure 2.10 Shipowner Questionnaire (Continued)

	Percent of All Casualty Costs Covered by Insurance		Number of Casualties Involved
	Marine Insurance	Self Insurance	
Tankers			
Hull	27.2%	72.8%	1,251
P & I	6.3	93.7	3,968
General Cargo			
Hull	65.3	34.7	2,195
P & I	26.1	73.9	93,456
Container Ships			
Hull	58.7	41.3	399
P & I	18.7	81.3	3,771
Dry Bulk Ships			
Hull	(Insufficient)		
P & I	Response)		
[Note: Based on responses received from 9 of 17 major U.S. shipping companies surveyed]			

Figure 2.11 Summary of Survey Results, Retained Risk Marine Insurance Practices of Owners (1970-1974)

However, this is the total marine insurance market, and it fails to distinguish the source of the premiums classified by:

- Ocean marine related to merchant shipping as opposed to marine (which would include yachts, air cargo, inland waterways, oil drilling rigs and pipelines, ferries and fishing vessels, and tugs and barges)
- U.S. ships under other flags
- U.S. marine insurance company writings relative to foreign marine insurance company writings.

A survey of 254 U.S. flag subsidized vessels (most probably an unrepresentative example) for the years 1965 to 1970 by Kirman [34] revealed the following distribution of insurance premiums:

25.5%	Hull
15.4	P & I
59.1	Cargo
100.0	Total Ocean Marine, Merchant Shipping

and further:

42.2%	Total Ocean Marine, Merchant Shipping
51.8	All Other Marine
100.0	Total Ocean Marine, U.S. Writings.

For all ships on U.S. trade routes, the Kirman study [34, p.5] estimated that: only 11% to 15% of the hull insurance would go to non-U.S. insurance companies; 43% of the cargo insurance would go to non-U.S. insurance companies.

The American Hull Insurance Syndicate has increased its share of the hull market since the Kirman study, and it is unlikely that non-U.S. insurance companies now have more than 10% of market. On the other hand, the small share of the U.S. in the P & I market has shrunk further, and it is conservatively estimated that non-U.S. insurance companies have at least 90% of this market.

However, it is still not possible to complete a construction of the ocean marine insurance market since this survey and the mail survey of the previous section are not truly representative and the three cross-classifications are still lacking.

2.4.3 The Results

As the results of the two previous sections indicate, no final conclusions as to the distribution of the initial benefits of SEASAT in the ocean routing process can be estimated because of gaps in the data about the marine insurance industry and because of deficiencies in the data available. Nevertheless, a few important conclusions can be stated:

- All reductions in operating costs due to time savings will initially accrue to shipowners
- Of reductions in hull damage to U.S. tankers 73% will initially accrue to shipowners and 27% to insurance companies
- Of reductions in P & I costs to U.S. tankers 94% will initially accrue to shipowners and 8% to insurance companies

- Of reductions in hull damage to U.S. general cargo ships, 35% will initially accrue to ship-owners and 65% to insurance companies

- Of reduction in P & I damage to U.S. general cargo ships, 74% will initially accrue to ship-owners and 26% to insurance companies

- Of reductions in damage to U.S. container ships, 41% will initially accrue to shipowners and 59% to insurance companies

- Of the reduction in P & I costs to U.S. container ships, 81% will initially accrue to shipowners and 19% to insurance companies

- Of reductions in hull damage to all ships on U.S. trade routes, 90% of insurance company benefits will accrue to U.S. insurance companies, 10% to non-U.S. insurance companies

- Of reductions in P & I costs to all ships on U.S. trade routes, 10% of insurance company bene-fits will accrue to U.S. insurance companies, 90% to non-U.S. insurance companies

- Of reductions in cargo losses for all ships on U.S. trade routes, 57% of insurance company bene-fits will accrue to U.S. insurance companies, 43% to non-U.S. insurance companies.

3. BENEFITS TO DRY CARGO SHIPPING, CASE STUDY AND GENERALIZATION

Estimates of the benefits of SEASAT data to dry cargo shipping are presented in this section. Estimates of the benefits to tankers are presented in Section 4.0. Since the dry cargo study pertained to shipping on U.S. trade routes for which there is a large amount of data on casualties, routing experience, cargo carried, and weather conditions, a modeling approach was taken to estimate the benefits. The tanker portion of the study dealt with the world tanker routes and the world tanker fleet and employed a statistical approach to estimate benefits.

Forecasts of dry cargo trade flows are developed by U.S. trade route by type vessel. The damage and time delays for vessels using these routes were obtained. A specific route and vessel (container ships on the North Atlantic trade route #5) were selected for case study. Benefits are estimated for the case study example. These results are first generalized to all U.S. trade routes and then to world trade.

3.1 U.S. Trade Route Forecasts, Dry Cargo

In order to provide shipping demand on specific routes for this case study, for other case studies, and to support all the generalizations, detailed forecasts were prepared for all major U.S. trade routes. Four major types of vessels were distinguished on each trade route:

- Containers
- Bulk liquid (e.g. oil)
- Dry bulk (e.g. wheat)
- Break bulk.

Break bulk ships, sometimes called general cargo ships, and containers usually carry cargo which is "counted." Bulk liquid and dry bulk ships carry cargo which is "measured."

It was necessary to make estimates cross-classified by both:

- Major type of vessel
- Trade route

because weather-related casualties and operating time losses vary greatly by vessel type and by location (trade route). Also, these losses vary with the time of year. So, where possible, quarterly data were sought, and weighted yearly averages were used.

3.1.1 Description of Forecasting System

The econometric forecasting model is presented in Figure 3.1, the ECON Econometric Forecasting Model. The analysis is first done on a total volume flow by route basis. This involves summing up the quantities on a route for each year (formula 1.2, Figure 3.1) and performing regression analysis on the basis explanatory variables such as income, population, and prices (formula 1.3, Figure 3.1). Variations of formula 1.3 are employed until a satisfactory fit is obtained. Cross-section

Formula

1.1 $$\sum_{r=1}^{R} x_{rkt} \equiv w_{kt} \text{ from } X_t$$

1.2 $$\sum_{k=1}^{K} x_{rkt} \equiv w_{rt} \text{ from } X_t$$

1.3 $$w_{rt} = w_{ijt} = \alpha\, y_i^{\beta 1}\, y_j^{\beta 2}\, n_i^{\beta 3}\, n_j^{\beta 4}\, p_j^{\beta 5}\, p_{ij}^{\beta 6}\, p_{ih}^{\beta 7}$$

1.4 $$A_{rt} = A_{r1}\, T_{ar}^{t}$$

1.5 $$B_{rt} = B_{r1}\, T_{br}^{t}$$

1.6 $$w_{rtg} = w_{rt}\, a_{rtg}\, b_{rtg}$$

Dimensions

i - origin

j - destination

r - trade route i to j or j to i

k - type commodity

h - all other trade areas

t - year

g - transport homogeneous group

Figure 3.1 The ECON Econometric Forecasting Model

Coefficients

α - scaling factor which equates units on each side of equation

β - elasticity of exports w (or imports w) to the variable attached

x - tons imported or exported, by route by type commodity by year

w - tons imported or exported, by route by year

y - GNP (gross national product)

n - population

p - price or price index

a - market share of imports or exports, by route by major THG by year, in %

b - market share of imports or exports, by route by minor THG by year, in %

Matrixes

X - Basic trade data matrix composed of x's

A - Market share vector, by route by major THG's by year

B - Market share vector, by route by minor THG's by year

T_a - Basic Markov Transition matrix, by route by major THG's by year

T_b - Basic Markov Transition matrix, by route by minor THG's by year

DEFINITIONS: [Note: Capital letters indicate a matrix or vector.]

Figure 3.1 The ECON Econometric Forecasting Model (Continued) and time series data are pooled to provide enough observations to make reasonable estimates. So, for example, three South Atlantic trade routes to Europe may provide twenty subroutes, and, with data from three years, there will be a total of sixty observations (=3x20) from which to estimate the coefficients. Subjective judgment must be used at this stage, since it is not sufficient to obtain the highest coefficient of regression. The economic theory underlying the final equation must be sound. The fact that the coefficients (the α's and the β's) can be interpreted as elasticities is a useful fact in this effort. An elasticity is a ratio of the percentage change in one variable relative to a percentage change in another variable. Thus a -.90 elasticity of demand for trade relative to the price in the other country (β5) means that a 10% rise in the prices of the other country results in a 9% drop in trade (elasticity = β5 = 9%/-10% = -.9). When the fit is significant and the elasticities make economic sense, a useful model has been obtained for a given route.

Once the model is fit, a forecast of the exogenous variables (income, prices, and population) is made usually from a minimum of seven years of past data. This is done for the section of the U.S. into which the trade flows or from which it emanates and for the foreign trading partner country. These values are fed into the model successively, and a forecast is made for as far out as desired. Of course, the further out in time the forecast, the greater the forecast error expected. An example of this output is presented in Figure 3.2, Example of Trade Route Forecasts.

In addition to the forecast of the total volume, a forecast of the market share by each type of vessel (containers, break bulk, and dry bulk - liquid bulk has been ignored here) is developed. Liquid bulk estimates are dealt with extensively elsewhere in this study because of the special importance of petroleum. The forecast of the market share is done by grouping the original trade data into transport homogeneous groups (THG). THG's are defined as groups of commodities which have characteristics which are similar from a transportation point of view. These characteristics include the general nature of the good (package or bulk, containerizable or not), the density (lbs/ft^3) and the value (dollar/lb). This type analysis was done by Planning Research Corporation for the Department of Transportation in Transoceanic Cargo Study, Los Angeles, California, March 1971. A cluster analysis was performed and nineteen basic THG's identified. These are presented in Figure 3.3. A mapping exercise was then performed which mapped the commodities in the U.S. Bureau of the Census Series A and Series B into the THG's. The mapping, which was not complete because of new codes, was updated by criteria in the New York Port Authority Containerization: Full Speed Ahead and in Litton Systems, Inc., Oceanborne Shipping: Demand and Technology Forecast, Culver City, California, 1968. A portion of

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities (Imports - in mil. lbs)				
	U.S. North Atlantic Trade Routes			
Year	05	06	07	08
History				
1973	3,567	5,387	3,194	6,622
($ per lb.)	.243	.047	.223	.189
Forecast				
1985	6,696	11,017	6,411	12,859
1986	6,915	11,857	6,840	13,682
1987	7,141	12,699	7,299	14,558
1988	7,374	13,600	7,788	15,489
1989	7,615	14,566	8,310	16,481
1990	7,864	15,600	8,866	17,535
1991	8,120	16,708	9,460	18,658
1992	8,386	17,894	10,094	19,852
1993	8,660	19,165	10,771	21,122
1994	8,943	20,525	11,492	22,474
1995	9,235	21,983	12,262	23,912
1996	9,536	23,543	13,084	25,443
1997	9,848	25,215	13,960	27,071
1998	10,170	27,005	14,896	28,804
1999	10,502	28,923	15,894	30,647
2000	10,845	30,976	16,959	32,609
Growth Rate Forecast, 1973-2000	3.3%	7.1%	6.7%	6.4%

Figure 3.2 Example of Trade Route Forecasts

	Criteria			
			Value Per Pound (in dollars)	
THG Number	Type Vessel	Density (lbs/ft^3)	Exports	Imports
1	Container, Reefer	40	0.11	0.228
2	Container	40	0.25	0.219
3	Container	75	1.25	0.446
4	Container	20	1.07	0.793
5	Container	150	0.62	0.522
6	Container	15	7.02	1.989
8	Bulk Liquid	50	0.007	0.007
10	Dry Bulk	250	0.010	0.005
11	Dry Bulk	50	0.005	0.005
12	Dry Bulk, Perishable	50	0.024	0.027
14	Dry Bulk	200	0.087	0.007
16	Dry Bulk, Perishable	40	0.046	0.098
20	Break Bulk (live animals)	5	1.345	5.004
21	Break Bulk	200	0.078	0.049
22	Break Bulk	30	0.021	0.025
23	Break Bulk	30	0.086	0.059
24	Break Bulk	60	0.228	0.073
25	Break Bulk	30	0.097	0.220
26	Break Bulk	30	1.033	0.705
Source: Planning Research Corporation [31]				

Figure 3.3 Transport Homogeneous Commodity Groups (THG)

the completed map is presented in Figure 3.4. The Department of Transportation Transoceanic Codes (DOTTO) appear in the Figure although they were not used in these forecasts.

From this effort, major groupings of commodities, called major THGs, are identified (groups of commodities which would be transported by container, liquid bulk, dry bulk, and break bulk ships, respectively). There are also minor THGs, which are clusters of commodities within the major groups.

An example of how these trade data are finally grouped by route, by year, and by major and minor THG, is presented in Figure 3.5, Example of Computer Output, Trade Route #5. The output in Figure 3.5 is an example of the final form in which the trade data are used. There is a series of six computer programs that are used to generate the ship forecasts, and Figure 3.5 is output from the second of these programs.

The six computer programs in the system are:

1. SAT 1 - groups the monthly data, provided by MARAD from their TRACE program which processes Bureau of the Census data into annual data

2. SAT 2 - groups trade data by route by year by THG

3. SAT 3 - calculates market shares by route by year by THG

4. SAT 4 - makes forecasts of market shares by year by route by THG

5. SAT 5 - prepares trade data and country data for regression analysis

6. SAT 6 - makes forecasts of trade volume by route by year.

Imports			Exports		
A	DOTTO	THG	B	DOTTO	LNG
001	001	20	001	001	20
011	011	01	011	011	01
012	014	02	012	014	02
013	014	02	013	014	02
022	999	02	022	999	02
023	027	01	023	027	01
024	024	02	025	025	02
025	025	02	031	034	04
031	999	01	031	034	04
032	034	04	032	034	04
041	041	12	033	033	01
042	042	23	041	041	12
043	043	12	042	042	23
044	044	12	043	043	12
045	999	12	044	044	12
046	047	22	045	999	12
047	050	23	046	047	22
048	999	23	047	050	23
051	999	01	048	999	22
052	056	02	051	999	01
053	999	02	052	056	02
054	999	01	053	999	01
055	063	02	054	999	01
061	999	23	055	064	02
062	066	23	061	999	23
071	076	25	062	066	23
072	999	23	071	076	25
073	079	02	072	999	25
074	074	02	073	076	23
075	075	02	074	074	02
079	074	02	075	075	02
081	999	22	081	081	22
091	091	01	091	091	01
099	099	02	111	111	02
111	111	02	112	112	02
112	112	02	121	121	04
122	122	04	211	211	25
211	211	25	212	212	06
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Figure 3.4 Cross-Classification of Schedules A and B, Department of Transportation Transoceanic Code, and Transport Homogeneous Groups

THG		Total ($)	Total (lbs)	U.S. ($)	U.S. (lbs)
Containers					
1	1973	27275453.	68359901.	18849049.	46219892.
	1972	12587126.	59702661.	7522559.	32848905.
	1971	9663248.	78949842.	4610802.	37972405.
2	1973	358743075.	720458086.	154817551.	302803487.
	1972	337666627.	633731219.	140332074.	268693768.
	1971	409522445.	697234204.	166548542.	278334436.
3	1973	40261382.	136655090.	32183092.	148202943.
	1972	37278115.	116426756.	27340545.	105907291.
	1971	44125398.	115638447.	25848318.	83446809.
4	1973	110525558.	439936990.	108791612.	484109809.
	1972	96847630.	421994878.	99707661.	438376645.
	1971	142648424.	439657912.	132543017.	391476637.
5	1973	8279685.	43743871.	7450231.	52513755.
	1972	6727207.	29100436.	4488617.	44257914.
	1971	7279480.	25789105.	4382180.	36779852.
6	1973	49299529.	147829036.	48286006.	161311668.
	1972	53654661.	132963942.	46243870.	122986847.
	1971	66624747.	126131263.	47624397.	94743033.
Bulk Liquid					
8	1973	0.	98602000.	0.	991317.
	1972	0.	121327920.	0.	1375008.
	1971	0.	45669619.	0.	433509.
Dry Bulk					
10	1973	1102807.	1554737.	305465.	640716.
	1972	4876641.	5528535.	360916.	735670.
	1971	234729.	4483902.	39960.	581318.
11	1973	50212354.	648048082.	1169651.	26104094.
	1972	104268053.	224148357.	1403221.	11272463.
	1971	9780687.	1204170956.	266562.	8715606.
12	1973	616000.	616000.	32190.	32190.
	1972	0.	0.	0.	0.
	1971	0.	0.	0.	0.
14	1973	25929395.	48184070.	2924713.	5972145.
	1972	20971924.	38186840.	2512760.	4112565.
	1971	18765561.	44477400.	2030676.	3682208.
16	1973	106680.	113857.	16107.	18499.
	1972	623478.	660548.	70732.	74397.
	1971	637903.	638945.	65617.	66203.

Figure 3.5 Example of Computer Output, Trade Route #5

Break Bulk					
THG		Total ($)	Total (lbs)	U.S. ($)	U.S. (lbs)
	1973	0.	26290.	0.	20864.
20	1972	0.	24006.	0.	108368.
	1971	0.	28211.	0.	27845.
	1973	14019160.	375521898.	3310679.	35018738.
21	1972	12579856.	411365379.	3562601.	33560973.
	1971	15325269.	673994111.	4231159.	47753317.
	1973	20925959.	252527938.	7202785.	17092484.
22	1972	18014542.	39758573.	3014849.	8022738.
	1971	12959184.	39523153.	2050784.	5238001.
	1973	62012161.	350268541.	25036660.	79777685.
23	1972	47345672.	150605668.	19840277.	52799237.
	1971	35900888.	126843290.	14340417.	41147789.
	1973	32529896.	116882209.	9969226.	27222801.
24	1972	24814431.	111667432.	6711978.	22007752.
	1971	18585669.	89851261.	4005112.	17589427.
	1973	39907272.	129484544.	23823619.	77965430.
25	1972	40139113.	106165542.	24366928.	55364420.
	1971	46243823.	99491492.	25189381.	48494293.
	1973	23762581.	86968765.	21646368.	114637921.
26	1972	25740149.	81453297.	22596555.	90265746.
	1971	39894237.	144828981.	26930527.	90783399.
Totals					
	1973	865508947.	3665781905.	465815004.	1580656438.
	1972	844135225.	2684811989.	410076143.	1292770707.
	1971	878191692.	3957402094.	460707451.	1187266177.

Figure 3.5 Example of Computer Output, Trade Route #5 (Continued)

It was necessary to develop six separate programs to provide flexibility in operation. Individual programs may be run to update portions of intermediate data, or the individual programs may be run in varying sequences depending on the specific goal.

The market shares to the individual THG's are generated by processing the output of SAT 2 through SAT 3 and SAT 4.

SAT 3 converts the shares realized in the past into percentage figures. Many trade forecasting schemes use these given percentage figures or constant shares as the norm for forecasting shares. However, this is unreasonable since the shares are evolving over time. Therefore, the rate of transition is estimated using a Markov model. Transition matrices for major THG's (T_{ar}) and minor THG's (T_{br}) are estimated in SAT 4 by a classical restricted least squares estimation method which employs a standard quadratic programming algorithm. The alternative estimating procedures are discussed in Lee, Judge, and Zellner, Estimating the Parameters of the Markov Probability Model from Aggregate Time Series Data, Amsterdam: North Holland Publishing Company, 1973.

The market shares for the major THG's and the minor THG's are calculated by SAT 5 using formula 1.4 and 1.5, respectively, from Figure 3.1, The ECON Econometric Forecasting Model. The actual volume of trade in any category may then be derived by a simple multiplication of the appropriate elements according to formula 1.6. If the forecast is for a very long time, it may not be necessary to raise the transition matrix to power t. Rather, since the matrices are reqular ergodic chains, the long-run limit is derived analytically by some basic algebra. An example of this type of output from SAT 4 is presented in Figure 3.6, Detailed Forecast by Trade Route, Imports.

		05		06	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	37.9%	46.3%	25.1%	25.7%
1	Container, Reefer	5.0	7.2	25.3	32.1
2	Container	48.0	50.6	28.4	[illegible]5.6
3	Container	7.7	8.4	6.2	8.8
4	Container	29.2	25.1	17.8	19.2
5	Container	1.6	2.2	12.3	14.3
6	Container	8.5			
	Dry Bulk Share of Total*	32.1	20.3	22.5	21.7
10	Dry Bulk	.8	2.2	33.2	21.0
11	Dry Bulk	91.0	89.8	66.1	71.0
12	Dry Bulk, Perishable	0.0	0.0	0.0	0.0
14	Dry Bulk	0.0	0.0	0.0	0.0
16	Dry Bulk, Perishable	0.0	0.0	0.0	0.0
	Break Bulk Share of Total**	30.0	33.4	52.4	52.6
20	Break Bulk (live animals)	0.1	0.0	0.0	0.0
21	Break Bulk	50.3	54.6	13.4	17.1
22	Break Bulk	3.9	4.0	42.1	44.1
23	Break Bulk	12.5	13.2	31.7	35.2
24	Break Bulk	8.9	8.6	8.5	2.4
25	Break Bulk	9.7	7.2	8.2	3.0
26	Break Bulk	14.4	17.4	1.1	1.2

* Total-excluding Liquid Bulk
** Forecast Share

Figure 3.6 Detailed Forecast by Trade Routes, Imports

This overall scheme for deriving the forecasts is illustrated in Figure 3.7, ECON Foreign Trade and Ship Forecasting System with Data Base. The basic data in the ECON system consist of:

1. The cross-classification table of series A & B
2. The route-by-route trade tapes with monthly A & B data from the MARAD TRACE program
3. Income, price, and population data.

There are two lines of development in the system:

1. SAT 2 - SAT 5 - SAT 6 which leads to a forecast of the total volume of trade by route (see Figure 13)
2. SAT 2 - SAT 3 - SAT 4 which leads to a forecast of market shares by route by THG (see Figure 17).

3.1.2 U.S. Trade Route Forecast Results

Using the forecasting system as described in the previous section, forecasts were made for all U.S. trade routes, imports and exports, 1985-2000; total flows; and market shares, to each THG. The results for the total flows and market shares are presented in Appendices A through D.

The data used besides the U.S. Maritime Administration trade tape data, 1971-1973, included:

- N = Population (in millions) [1967-1973] obtained from:

  Department of Economics and Social Affairs, U.N. Monthly Bulletin of Statistics, N.Y.: U.N., February 1975, pp. 1-4.

- Y = National Income (millions of U.S. dollars) (constant base year: 1963) [1967-1973] obtained from:

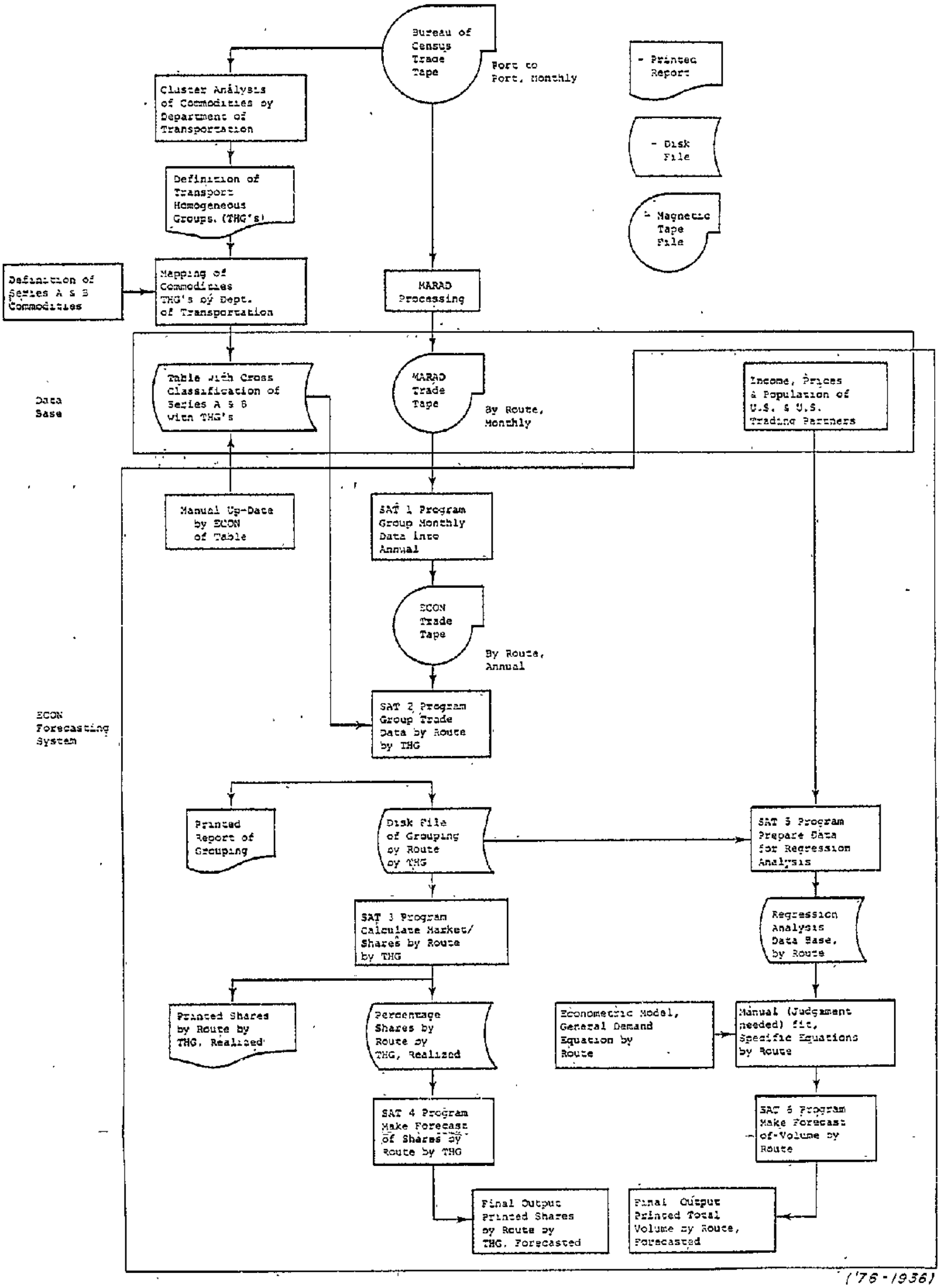

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Figure 3.7 ECON Foreign Trade and Ship Forecasting System with Data Base

Department of Economics and Social Affairs, U.N. Yearbook of National Accounts Statistics, N.Y.: U.N., 1973, Vol. III, pp. 8-12.

Department of Economics and Social Affairs, U.N. Yearbook of National Accounts Statistics, N.Y.: U.N., 1972, Vol. III, pp. 8-12.

- P = Price Index (base: 1970=100) [1967-1973] obtained from:

  Department of Economics and Social Affairs, U.N. Monthly Bulletin of Statistics, N.Y.: U.N., February, 1975.

The forecasting system is capable of handling estimation at the minor route level, the major route level, or the trade area level. The present forecast was made at the trade area level. The grouping of trade routes is presented in Figure 3.8, Definition of Trade Areas. By pooling cross-section and time series data for 1971-1973, the basic import and export equations were fitted. The results are presented in Figures 3.9 and 3.10, Forecasting Equations, Exports, and Imports. Data from the income, price, and population series for each country were grouped to provide income, price, and population series for each trade route for 1967 to 1973. These time series were extrapolated using the basic exponential growth equation:

$$Y = A\ e^{\lambda t}$$

where Y was the income, price, or population series to be extrapolated; λ was the growth rate estimated from the 1967-1973 data; and t was time. These results, together with the Forecasting Equations in Figures 3.9 and 3.10, were used to generate

Trade Areas	Trade Routes
U.S. North Atlantic	
1	05 06 07 08 09
2	10
U.S. South Atlantic and Gulf	
3	11 21
4	13
U.S. Pacific	
5	26
6	43 65
7	38 53
8	24
9	25
10	37 38 83
U.S. Total	
11	04 19 23
12	71 72 77 78
13	85 86 87
14	16 27
15	17 91 92 93
U.S. Atlantic and Gulf	
16	41 42
17	51 52
18	35 36 81 82
19	12 18 22 28 29
20	01 20
21	02 31
U.S. Great Lakes	
22	32 34
23	33 80 84
24	54 55 56 59 60 89
25	61
26	58

Figure 3.8 Definition of Table Areas. (A List of U.S. Trade Routes is presented in Appendix E)

Trade Area Groupings	Forecasting Equations	R^2
Trade Areas 1,2	$W = 138.4\ P_{U.S.}^{-0.92}\ N_{HR}^{0.46}\ Y_{HR}^{0.74}$	.82
Trade Areas 3,4,18	$W = 57.89\ Y_{U.S.}^{3.12}\ P_{HR}^{0.51}$	.48
Trade Areas 5,7,8,9,10	$W = 699.2\ N_{U.S.}^{1.82}\ Y_{HR}^{1.23}\ P_{H}^{0.48}$	.49
Trade Area 11	$W = 1{,}174.\ Y_{U.S.}^{4.72}\ P_{HR}^{0.58}$	.55
Trade Areas 14,15	$W = 1{,}922.\ Y_{U.S.}^{2.13}\ Y_{HR}^{.72}$	.79
Trade Areas 16,19,20,21	$W = 37.44\ N_{U.S.}^{.54}\ Y_{HR}^{.29}\ P_{HR}^{1.40}$	.72
Trade Areas 22,23	$W = 2.084\ Y_{U.S.}^{1.92}\ N_{HR}^{2.04}$	.69

where U.S. - United States Area
HR - Other Trading Partner
H - All Other Trading Partners

Figure 3.9 Forecasting Equations, Exports

Trade Area Groupings	Forecasting Equations	R^2
Trade Areas 1,2	$W = 2,780.\ P_{U.S.}^{0.68}\ N_{HR}^{0.21}$	.68
Trade Areas 3,4,18	$W = 415.9\ P_{HR}^{-0.14}\ Y_{HR}^{1.07}$	.78
Trade Areas 5,6,7,8,9,10	$W = 3.486\ N_{HR}^{0.95}\ P_{HR}^{-0.72}$	.75
Trade Areas 11,12	$W = 1524.\ P_{HR}^{-0.36}\ Y_{HR}^{1.09}$	.68
Trade Areas 13,25,26	$W = 25.99\ P_{U.S.}^{2.33}\ N_{U.S.}^{4.83}\ Y_{HR}^{0.92}$	.58
Trade Areas 14,15	$W = 2,884.\ N_{HR}^{0.46}\ P_{HR}^{-0.27}$	.84
Trade Areas 16,17	$W = 2.625\ P_{U.S.}^{0.37}\ Y_{U.S.}^{2.88}\ P_{HR}^{-0.91}$	.89
Trade Areas 19,20,21	$W = 1,232.\ Y_{HR}^{1.36}\ P_{HR}^{-1.65}$	.82
Trade Areas 22,23,24	$W = 162.1\ P_{HR}^{-1.03}\ Y_{HR}^{0.73}$	.70

where U.S. - United States
HR - Other Trading Partners
H - All Other Trading Partners

Figure 3.10 Forecasting Equations, Imports forecasts on all U.S. trade routes. The final results are presented in Appendix A and Appendix B.

Market shares were also forecast with the same U.S. Maritime Administration trade data using the methodology discussed in the section above - Description of Forecasting System. The above forecasts were generated for the major THGs but the forecasts for minor THGs were not developed at this time. These results are presented in Appendix C and Appendix D.

3.2 The Cost Parameters of Weather-Related Casualties and Time Delays

In order to estimate the reduction in weather-related damage and time loss possible with SEASAT, it was first necessary to ascertain the present adverse weather damage, damage costs, time losses, and operating costs as a function of time. A number of organizations make available useful statistics. These include:

- The U.S. Coast Guard
- The U.S. Salvage Association
- Lloyd's Register of Shipping
- Ocean Routes, Inc.

The first three organizations provide casualty data, and Ocean Routes keeps extensive computer records of ocean crossing times of routed and unrouted vessels. Numerous other sources of casualty data of various sorts are available, and a survey of these sources may be found in the Panel on Merchant Marine Casualty Data, <u>Merchant Marine Casualty Data</u> [23].

3.2.1 Expected Damage Costs by Vessel Type by Location

Because the satellite data will be used to avoid adverse weather damage, it was necessary to distinguish casualty statistics by:

- Cause (adverse weather or other)
- Vessel type
- Location of casualty
- Population of ships on average in casualty location.

This is necessary since adverse weather damage costs would vary with the type vessel while the probability of adverse weather varies with the location. In order to develop the probability figures needed, it is also desirable to have the population of ships (or "ships at risk" averaged by locations) for which casualties are known.

Unfortunately, there is no set of data available with all four variables specified at the present time. Lloyd's Register of Shipping is preparing such a study but does not expect the report to be available until summer of 1976.

The U.S. Salvage Association (USSA) keeps extensive computer files on casualties and was able to generate casualty data cross-classified by 3 of the 4 variables: cause, vessel type, and location. The USSA is the technical arm of the American Hull Insurance Syndicate (AHIS) which may have approximately 1,800 ships under coverage at any one time. Since the AHIS has no specific information on the location of each of these vessels, the population by location could not be obtained. The alleged causes included:

- Groundings
- Collision - object
- Collision - ship-to-ship
- Heavy weather damage (e.g., wave damage to hull)
- Material Failure, Vessel Structure, and Equipment
- All others.

The USSA coding includes many more categories of alleged causes than the five specifically selected, but a check of a U.S. Coast Guard tabulation indicated the first five alleged causes are especially weather sensitive (i.e., more likely to occur in adverse weather than casualties due to other causes). The tabulation was done for the period 1970 to 1974 inclusive for the alleged causes listed above, for major vessel types (grouped into 26 types for this special study), and for all major ocean shipping locations. The complete results are presented in Appendix F, Casualty Costs.

The results of this study provided absolute levels of casualty costs. However, there was no simple way to estimate the probability that a casualty would occur. The figures used in the case study below are therefore based on the interviews mentioned above with ship captains, marine insurance brokers, and shipping company personnel. Also, a study of ship damage to 100 dry cargo ships over a one-year period was conducted in 1963, for American flag ships on all major routes (see Townsend and Hamrin [26]). These vessels experienced 312 casualties over this one-year period. The two most costly casualty causes were bottom damage in adverse weather (22 casualties with repair costs of $440,574, 1963 dollars) and striking piers and docks (56 casualties with repair costs of $458,776, 1963 dollars). These two categories together account for 40% of all casualty costs incurred by the 100 ships during the year. However, strikes at piers and docks is a casualty type which can not benefit from the use of satellite data in the routing procedure examined in this study. This is true of most casualties since the vast majority occur at the entrance to ports and harbors or at piers and docks. Their prevention requires better "local" weather forecasts.

This study, together with the interviews mentioned above, led to the conclusion that only about 10% of all casualties can be attributed to adverse weather in the open seas. For example, of the 312 casualties experienced by the 100 vessels in one year, perhaps 25 to 35 of these would fall into this category. This implies:

- The probability of a dry cargo vessel experiencing an adverse weather-related casualty on the open seas in one year is about 30% (or a ship can expect to incur such a casualty almost once every three years).

This figure is a rough estimate for all U.S. trade routes based on subjective experience. Since the severity of the weather varies by route, special attention was given to the

North Atlantic trade route for which the case study was conducted. This route is more treacherous than most others and the probability of such an adverse weather casualty was roughly estimated (by comparison with the conclusion immediately above) to be about 33% by those interviewed. It is this 33% figure which is used in the case study example.

3.2.2 Expected Time Losses by Trade Route

In an attempt to estimate the reduction in delay time possible due to ocean routing, time and distance figures were collected by route, by direction, by season, and by vessel type for routed and unrouted vessels. The number of ships in each sample group and the standard deviations in delay time were also compiled.

The study was restricted to four basic vessel types:

Vessel Type	Rated Speed	Operating Cost/Day
Tanker	15.5 knots	$13,000-15,000
Freighter	19.5 knots	12,000-18,000
Container	22.5 knots	16,000-30,000
Dry Bulk	15.0 knots	10,000-14,000

The routes examined included:

- Pacific
  - a. Pacific Northwest to Japan and Return
  - b. West Coast (California) to Japan and Return
  - c. Panama to Japan and Return
- Atlantic
  - a. East Coast to Northern Europe and Return
  - b. East Coast to the Mediterranean and Return

- Gulf of Mexico

  a. U.S. Gulf to Northern Europe and Return
  b. U.S. Gulf to the Mediterranean and Return.

Information was collected by Ocean Routes, Inc., for ships which they routed and for unrouted ships from routine weather reports from ships on the same routes. The complete results of this tabulation (mean distance, mean time, sample size, and standard deviation of mean time) are presented for each route in Appendix G, Ocean Crossing Times.

The mean distance and mean time figures may be directly analyzed. But a few points can be made about the standard deviation figures:

- The standard deviations on some routes are unusually large. This is due to the small sample size that was available for some ship types (notably unrouted container ships).

- Ships which are weather routed, generally, tend to deviate less from the mean than those which are unrouted.

- Smaller deviations occur for container ships and freighters. The main reason for this is that their speed:

  a. Enables them to more easily go around weather systems.

  b. Often allows them to stay in front of a weather system.

  c. Allows them to more quickly pass through a weather system if they are unable to avoid it completely.

- The tankers and bulkers have greater deviations from the average because of their slow speed, which both makes it more difficult for them to avoid weather systems as well as exposing them to a greater number of weather systems because of their longer voyage times.

The identical route was not followed in each case, and care must be used in the interpretation of the figures. A check can be made against the difference in the absolute level of crossing time by use of the average speed in knots. Theoretically, if routed ships are avoiding adverse weather more than unrouted ships, their average speed should be proportionately higher regardless of the exact route. Sometimes ships may rely on routing to pass through the edge of storms if they can shorten their total distance travelled. In this case their average speed can be as slow as or slower than unrouted ships but their distance traveled can be much shorter. The use of these figures is made directly in the case study in Section 3.3.

3.3 The Case Study

In order to gauge the impact of SEASAT weather data more specifically, a case study on a single route for a single ship type was conducted. A model was designed to estimate the benefits of these data in the chosen case study. The previously collected casualty costs, delay time, and shipping forecasts were drawn upon to quantify the variables within the model. Where subjective estimates were required, specialists in the present routing procedures were called upon. These included personnel at Ocean Routes, Inc.; Bendix Commercial Services, Inc.; FNWC Norfolk; FNWC Monterey; and ship captains and personnel from shipping companies using the routing procedures on the case study route. The results of the case study are presented in Section 3.3.4. The summary of the case study results and their generalization are presented in Section 3.4.

3.3.1 Introduction

Benefits to SEASAT on the case study route had to be measured against some baseline value. Two baseline values were constructed:

1. Baseline I, the present system - the 1973 dollar cost, for one-way crossing, of casualty and delay times due to adverse weather, assuming present ocean crossing weather-related procedures do not change.

2. Baseline II, the modified system - the 1973 dollar cost, per one-way crossing, of casualty and delay time due to adverse weather, assuming present ocean crossing weather-related procedures are improved.

The equivalent 1973 dollar cost is calculated assuming the availability of SEASAT. The differences between this value and the two baseline values give alternative estimates of the benefit in the case study example. By comparing the characteristics of the case study route to the rest of the U.S. trade routes, a generalization of these results is made.

The estimation of the case study benefits involved the estimation of several variables for most of which only rough figures were available. It was not possible to quantify the uncertainty surrounding all the estimated values. However, the variation in the delay time was quantified and the impact is presented in Appendix G. This variable was chosen because of its central importance in the study. But it is not sufficient by itself to yield an estimate of the variation in final benefits estimated.

3.3.2 Selection of Trade Route and Vessel Type

There is no representative trade route and vessel type. This is because of the diversity among the limited number of types of vessels and because of the variation in conditions on the important U.S. trade routes. Thus, a selection could not be made on the basis of representativeness. The estimates of the benefits were made from a selected trade route and vessel type, and the results were generalized by taking note of the differences on the routes and vessel types not included in the cases.

The route selected was trade route number 5, U.S. North Atlantic to United Kingdom and Ireland. The vessel type selected was the container ship. These selections were based on the proximity of routers and shipping companies which use this route and on the fact that the trade was of a substantive size and value in recent years.

3.3.3 The Model and Input Data

The principal inputs in the calculation of the casualty and delay cost due to adverse weather were:

- The probability that routing is received
- The probability that routing once received is employed (the recommended route is often not followed)
- The probability that bad weather is encountered
- The probability that a casualty is incurred
- The expected delay time.

2

A network model was developed to quickly process the various permutations and to generate the expected delay time and the expected probability of a casualty in each system. This model is illustrated in standard network programming notation in Figure 3.11, Case Study Weather Casualty/Ocean Crossing Model.

To get the final results, it is necessary to multiply respectively by:

1. The cost per hour of delay time
2. The cost per casualty

The data collected and used as input in the model are presented in Figure 3.12, Model Input Data.

The data were developed as follows. Entries in 1 and 2 of Figure 3.12 were derived from interviews with the ship captains and ship routers mentioned above. Entries in 3 and 4 were derived from interviews but also verified by examination of the ship crossing times from Ocean Routes presented in Appendix G. It can be noted from those data that the average speed (as measured in knots) of routed ships is slightly faster than unrouted ships, indicating that the routed ships most likely spend less time in bad weather. Entries 5 and 6 were derived by interview and under certain assumptions. As indicated in Section 3.2.1, the probability of casualty can not be derived from published sources because of the lack of total population figures where a specific number of ships record casualties. Roughly, a ship can expect a significant casualty to occur once every

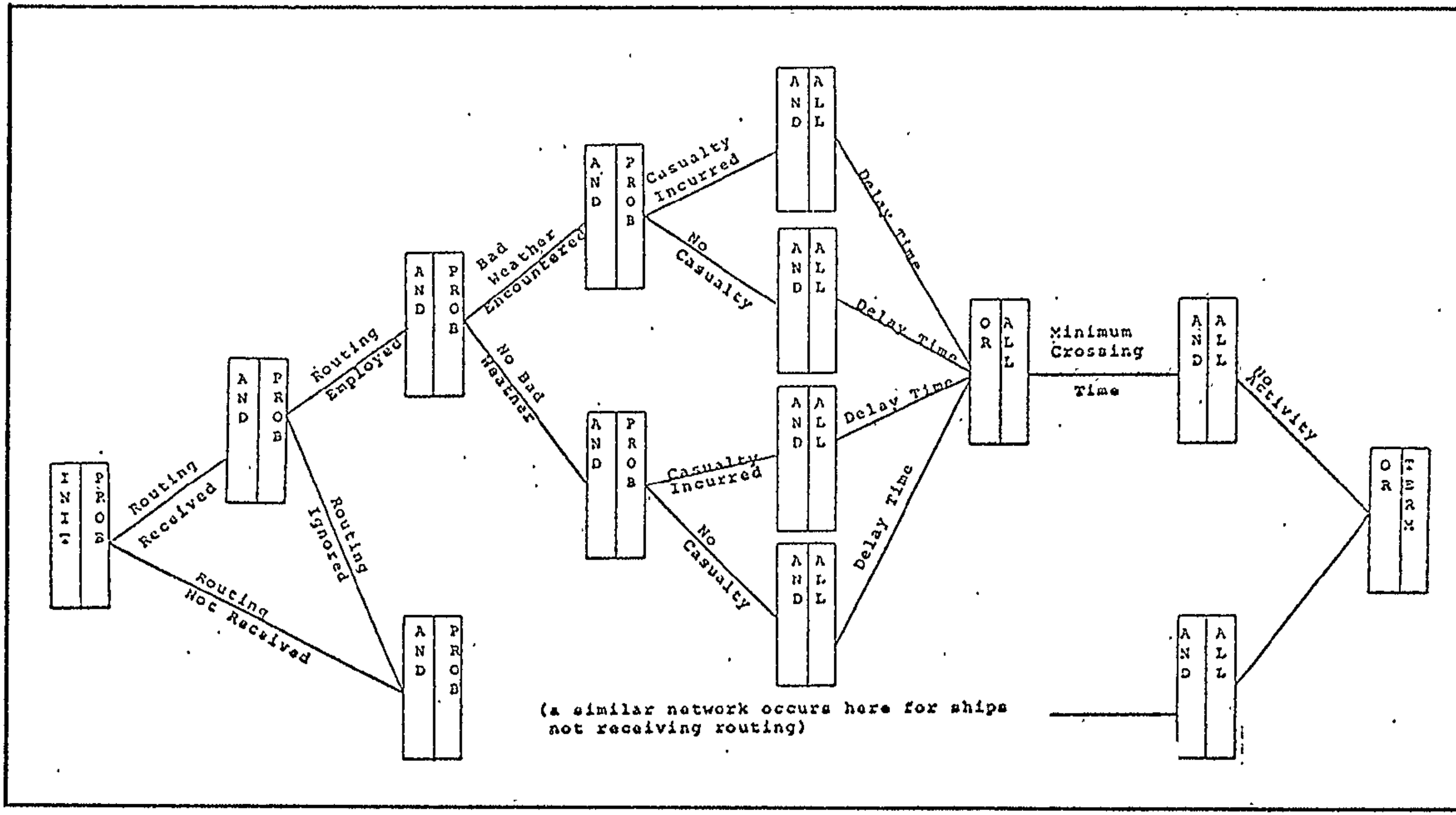

Figure 3.11 Case Study Weather Casualty/Ocean Crossing Model

1. Routing Received
   - A. Present System - 80% yes, 20% no.
   - B. Modified Present System - 85% yes, 15% no.
   - C. SEASAT Aided System - 90% yes, 10% no.
2. Routing Employed
   - A. Present System - 70% yes, 30% no.
   - B. Modified Present System - 75% yes, 25% no.
   - C. SEASAT Aided System - 80% yes, 20% no.
3. Bad Weather Encountered - With Routing
   - A. Present System - 30% of the time.
   - B. Modified Present System - 28% of the time.
   - C. SEASAT Aided System - 25% of the time.
4. Bad Weather Encountered - Without Routing
   - A. Present System - 33% of the time.
   - B. Modified Present System - 31% of the time.
   - C. SEASAT Aided System - 31% of the time.
5. Casualty Incurred - In Bad Weather
   - A. Present System - probability is .025
   - B. Modified Present System - probability is .025
   - C. SEASAT Aided System - probability is .025
6. Casualty Incurred - No Bad Weather
   - A. Present System - probability is .0027
   - B. Modified Present System - probability is .0027
   - C. SEASAT Aided System - probability is .0027

Figure 3.12 Model Input Data

7. Delay Time - With Routing and With Bad Weather

A. Present System - delay time is 23 (high) hours
5 (low)
14 (most likely)

B. Modified Present System - delay time is
23 (high) hours
5 (low)
13 (most likely)

C. SEASAT Aided System - delay time is
20 (high) hours
2 (low)
11 (most likely)

8. Delay Time - Without Routing and With Bad Weather

A. Present System - delay time is 26 (high) hours
8 (low)
17 (most likely)

B. Modified Present System - delay time is
25 (high) hours
7 (low)
16 (most likely)

C. SEASAT Aided System - delay time is
27 (high) hours
7 (low)
16 (most likely)

9. Delay Time - Without Bad Weather

A. Present System

(1) With Casualty - delay time is
11 (high) hours
5 (low)
8 (most likely)

(2) Without Casualty - delay time is
0 (high) hours
0 (low)
0 (most likely)

Figure 3.12 Model Input Data (Continued)

B. Modified Present System

(1) With Casualty - delay time is
11 (high) hours
5 (low)
8 (most likely)

(2) Without Casualty - delay time is
0 (high) hours
0 (low)
0 (most likely)

C. SEASAT Aided System

(1) With Casualty - delay time is
11 (high) hours
5 (low)
8 (most likely)

(2) Without Casualty - delay time is
0 (high) hours
0 (low)
0 (most likely)

10. <u>Minimum Crossing Time</u>

A. Present System - 145 (high) hours
145 (low)
145 (most likely)

B. Modified Present System - 145 (high) hours
145 (low)
145 (most likely)

Figure 3.12 Model Input Data (Continued)

three years, and it is highly probable that the casualty will occur in adverse weather. It was thus assumed that a container ship could normally complete 40 one-way ocean crossings in one year, that the probability of incurring a casualty in one year is .33, and that the ratio of bad weather casualities to good weather casualties is 9 to 1 (or 3 to 1/3). The respective

Bayesian probabilities that, if a casualty occurred, it occurred in bad weather, lead to

$$(3)\ (.33)\ (1/40) = .025$$

and in good weather

$$(1/3)(.33)(1/40) = .0027.$$

Delay times were calculated from 27 unrouted and 238 routed crossings of the North Atlantic by container ships. The respective crossing times were:

162 hrs. ± 8 hrs. - unrouted crossing

159 hrs. ± 10 hrs. - routed crossing.

Therefore, the difference and the standard error of the difference are:

3 hrs. ± 1.67 hrs.

This means there is a significant difference in routed and unrouted times at the 93% level of confidence. However, the data are taken from ships which may have followed slightly different routes. If we take the average speed on these crossings, we find:

20.2 knots - unrouted ships

20.4 knots - routed ships

Thus, there is a one percent gain in speed for routed ships which would indicate a relative gain of a bit less than two hours. Therefore, it was felt that the estimate of 3 ± 1.67 hours was a reasonable figure. This 3-hour difference with bad weather represents the difference between delay time for unrouted and routed ships (17 hours minus 14 hours). The levels were gotten directly by taking the (average actual crossing time) minus (crossing distance divided by average speed, 22.5 knots). The high and low ranges are approximately one standard deviation. From interviews, it was estimated that improvements in the present system were possible but that the present routing gain could not be duplicated. Therefore, it was assumed after interviews that a modified version of the present system could result in a reduction in percent of time that bad weather was encountered of 2% (e.g., from 30% to 28%) and a reduction in delay time of 1 hour (e.g., from 14 to 13 hours). This is consistent with the rate of progress in forecasting indicated by the International Meterological Society in Section 2.3.3. Marked improvements can be made in forecasting if sea surface temperature can be obtained such as with the microwave radiometer which is expected to be on the operational SEASAT from 1985-2000. Assuming this advantage from SEASAT and other data-gathering capabilities discussed above in this report, it was assumed that the previous gains from routing could be duplicated in avoiding bad weather (bad weather encountered 25%, versus 28% without SEASAT) and avoiding delay time (11 hours delay, versus 14 hours without SEASAT).

It was assumed that each container ship carried 17 thousand tons per crossing, that the total flow of cargo on trade route 5 was as indicated in the trade route forecasts of exports and imports, and that the market share of 31.4% weighted by respective export and import volumes for containers on this route would be realized as forecast in the market share analysis. The study of casualties provided by the U.S. Salvage Association indicated 43 reported casualties over 1971 to 1974 for container ships on the North Atlantic trade route, with an estimate of damage of $320,023 per casualty. This figure was used as a representative 1973 dollar estimate of the cost of a casualty. The 1973 dollar estimate of the cost of delay time was $750 per hour ($18,000 per day).

Thus, the principal formula used in the case study is:

$$TC = OC(DT)+CC(PC)$$

where

TC = total cost per crossing due to adverse weather

OC = Operating Cost ($ per hour)

DT = Delay Time (hours per crossing)

CC = Expected Casualty Cost ($ per casualty)

PC = Probability of Casualty (probability per crossing)

with DT and PC being the outputs of the network model.

The results of the case study and the generalization are presented in the next two sections.

3.3.4 The Results

The results of the model described in the previous section indicate the following. The cost due to casualties and delay time because of adverse weather under the present system is $6,751 per crossing in 1973 dollars. The modified system figure is $6,038, and the SEASAT figure is $5,311. These model outputs are summarized in Figure 3.13. Also presented in the Figure are the high and low values due to uncertainty surrounding the expected delay time.

Thus, the benefits to SEASAT are:

1. $1,440 per crossing in 1973 dollars, SEASAT versus present system.

2. $727 per crossing in 1973 dollars, SEASAT versus modified system.

The present system and the modified system are defined at the beginning of Section 3.3.1. These results seem consistent with existing practices. Many ship operators pay $200-$300 per crossing in direct fees for routing services as indicated above. Overhead expenses to supply pre-departure information, voyage data and communication, and past voyage data to the router would indicate the true value of present routing information is $500 to $700 per crossing. These benefit figures indicate that the present losses in casualty and delay time costs could be reduced by 10% to 25% with better sea conditions and weather information.

3.4 Generalization of the Results, Dry Cargo

The case study results of the previous section for container ships on the North Atlantic trade route number 5 found that the benefit attributable to SEASAT of reduced casualty and delay costs was $1,440 per crossing as measured

	Casualty	Delay		
	Expected Casualty Cost	Expected Delay Time	Expected Delay Costs	Total Costs
Present System				
High		7.66	5,745	8,844
Most Likely	3,099	4.87	3,652	6,751
Low		2.01	1,508	4,607
Modified System				
High		6.91	5,183	8,123
Most Likely	2,940	4.13	3,098	6,038
Low		1.69	1,268	4,208
SEASAT Aided System				
High		5.79	4,343	7,111
Most Likely	2,768	3.39	2,543	5,311
Low		.98	735	3,503

Figure 3.13 Expected Weather-Related Casualty and Delay Costs per One-Way Crossing by Container Ships on Trade Route #5 (1973 dollars; time in hours)

against the present system and $727 per crossing as measured against the modified system. These are in 1973 dollars and the present and modified systems are as defined at the beginning of Section 3.3.1.

In this section, the benefits are shifted to 1975 dollars. The discounted stream of benefits for 1985 to 2000 is calculated for the case study examples using a 10 percent discount rate. The similarities and dissimilarities between the case study vessel type and route and all vessel types, except liquid bulk, and of the U.S. trade routes are examined. Annual benefit figures and the stream of benefits for all U.S. trade routes are then calculated. A similar extrapolation is done to get global benefits. It was not possible to fully quantify the uncertainty underlying the case study benefits, and no measure of uncertainty was possible for the generalization to all U.S. trade routes and to global trade. Therefore, increasing caution must be exercised with the interpretation and reliability of the results at greater levels of generalization.

The 1973 dollar results in the case study were shifted to 1975 dollars by assuming a 9 percent per annum inflation factor which is a weighted average of several U.S. price indices for these 2 years. This yields benefit-per-crossing values of $1,699 (was $1,440 in 1973 dollars) and $858 (was $727 in 1973 dollars). The forecasts on trade route number 5 for containers for the years 1985-2000 were derived from the results found in Appendices A through D. It was assumed that a container ship could carry 17 thousand tons of cargo per crossing and make 40 one-way crossings per year. A stream of benefits was calculated. This stream was then discounted and summed to yield a present value total benefit figure. This procedure was followed once for SEASAT versus the present system and once for SEASAT versus the modified system.

The total dry cargo flows on all U.S. trade routes is growing at about 4 percent, and this rate is expected to be maintained in the period 1985-2000 according to the trade route forecasts. The total dry cargo flows globally were forecast to grow at a rate of 7 percent in the global econometric forecast described in Section 2.2.2. The relative magnitude of all dry cargo trade, tonnage, and value for U. S. trade route number 5, all U.S. trade routes, and global trade is presented in Figure 25.

The criteria used for generalization were the four elements in the principal formula used for calculation of the total cost per crossing due to adverse weather:

- Operating cost
- Time lost due to adverse weather
- Expected casualty cost
- Probability of casualty.

Focusing on U.S. trade routes first, the survey results by U.S. Salvage Association indicate that the average casualty estimated cost for ships surveyed was $82,429, which is considerably less then the $320,023 figure for containers on the North Atlantic. This may partially be accounted for by the fact that the container ships are principally modern, large, and American fleet ships and by the fact that the North Atlantic experiences especially treacherous weather. The American Hull Insurance Syndicate, for which the U.S. Salvage Association is the technical arm, insures ships of many flags which sail in all oceans of the world but principally on U.S. trade routes. Thus, these figures should be fairly representative for U.S. trade routes. While the expected casualty

	Total		Dry Cargo	
	Tonnage	Value	Tonnage	Value
Trade Route No. 5				
Total	7,019	.185	6,866	.211
Imports	3,665	.236	3,567	.243
Exports	3,354	.130	3,299	.176
All U.S. Trade Routes				
Total	1,414,721	.059	746,265	.100
Imports	908,474	.049	283,645	.134
Exports	506,247	.079	462,620	.079
World Seaborne Trade				
Total	6,206,365		2,563,992	

Sources: Trade Route No. 5 from Marad [24]; All U.S. Trade Routes from Marad [33, p. 73 and 74]; and World Totals from OECD [28, p. 105 with projections].

Figure 3.14 Trade Route No. 5 -- U.S. Foreign Seaborne Trade-1973 (Tonnage - in million pounds; and Value in dollars per pound)

cost is much higher for the container ships on trade route number 5 than for all types of vessels on all U.S. trade routes, this is partially offset by the fact that the probability of casualty is lower. Safety standards are not as high for non-U.S. flag ships, which carry the bulk of U. S. trade.

Examination of the time delays on other routes indicates higher speeds on average, 21.7 knots versus 20.3 knots, and smaller differences in total delay time between routed and unrouted ships. Using these rough figures and estimated 1973 dollar figures of $14,500 per day (versus $18,000 per day for container ships in the case study) for operating cost, an estimated weighted benefit ratio of .777 was derived. This ratio is the benefit on all U.S. routes for all vessel types, except liquid bulk, relative to the benefit to container ships on U.S. trade route number 5. Using this ratio, the case study benefits, and U.S. trade route forecasts, a generalized stream of benefits was generated, once for SEASAT versus the modified system and once for SEASAT versus the present system.

The final results of the case study and the generalization are presented in Figure 3.15. No attempt was made to generalize the results further to world trade because of the greater diversity in sea conditions, weather, vessel types, and vessel quality which would be difficult to quantify.

	Undiscounted Benefits			Cumulative Discounted Benefit*
	1985	1992	2000	1985-2000
Containers on				
Trade Route No. 5				
a. SEASAT versus Modified System	127,310	169,397	236,132	538,957
b. SEASAT versus Present System	252,126	335,475	467,640	1,067,362
All U.S. Trade Routes				
a. SEASAT versus Modified System	27,067,000	35,629,000	48,861,000	113,464,000
b. SEASAT versus Present System	53,604,415	70,561,000	96,765,000	224,707,000

* Using Discount Rate of 10%

Figure 3.15 Benefits to SEASAT from Reduced Casualty Costs and Delay Costs Due to Adverse Weather, in 1975 Dollars

4. BENEFITS TO TANKERS

4.1 Introduction

Dollar savings can be realized for tankers because of the time underway saved due to more perfect environmental information. Even if one considers that tankers could save dollars by using technology available today, a 10 to 15 percent increase when SEASAT becomes operational is a reasonable assumption.

This increment is based on past experience and the assumption that SEASAT will be able to provide the additional information stated. In the 1960's, when satellite information was first used in weather routing, there was about a 15 percent reduction in time underway. If SEASAT can provide information such as wave height and direction, surface winds, and ice information, an improvement of the same magnitude as when the original satellites were first used for weather routing is reasonable. These incremental dollar savings are a substantial amount, especially considering the high dollar operating costs of VLCC's and ULCC's, which will constitute approximately 60 percent of the total tanker tonnage in 1985. Because of the large number of ships that will be in service, operating savings provided by weather routing could be as much as $102,000,000 per year of which 10 to 15 percent could be considered to be incremental savings provided by SEASAT.

An additional projected cost of $37,700,000 per year to replace VLCC and ULCC tonnage lost due to weather could be decreased because of information SEASAT will provide. However, many weather losses occur in areas where better weather information could be of little use; therefore, this entire dollar figure cannot be considered as potential savings. The potential range is between 12 and 40 percent, or $4,500,000 to $15,000,000.

When past casualties were reviewed, the above fact came out quite clearly: that, although many losses can be prevented by weather routing, the majority occur in coastal waters where weather routing cannot be of much assistance. Furthermore, losses and damages to cargo can be reduced by weather routing, but this has no effect on tankers which carry no on-deck or damageable cargoes.

In summary, the greatest dollar savings would seem to come from time saved underway. Although some catastrophic losses will be prevented, the majority caused by weather occur in areas that ocean condition information can be of little assistance such as at the entrance to ports and at dock. In addition, tankers will not benefit from reduced cargo damage.

4.2 Tanker Trade Routes

For this study, the major world tanker trade routes and the weather-dependent alternatives associated with each were defined. See Figure 4.1, Trade Route Descriptions.

TR#	From	To	Weather Dependent Alternatives
1	California	Japan	Route north if high is over Gulf of Alaska/Bering Sea with lows tracking east-northeast from Japan at mid-latitudes or if "cut-off" lows develop north of Hawaii. Route south if lows follow standard track northeastward from Japan to the Aleutians, Gulf of Alaska and Pacific Northwest.
2	Japan	California	More southerly routes in winter due to the intensity of lows crossing the Pacific. Routes approaching Great Circle in summer as lows weaken and highs move eastward at higher altitude. In summer, routes also dependent on extent of fog.
3	Balboa	Japan	Coastal sailing along Mexican coast if gales anticipated in Gulf of Tehuantepec (Fall-Spring) southerly routes in winter as more favorable weather/currents offset added distance. Routes to the north in summer (but south of Great Circle) as lows weaken and track further north. Routes in Western Pacific in summer also dependent on recurring tropical storms/typhoons. Routes in the Eastern Pacific also dependent on existence of hurricanes south of Mexico in the summer.

Figure 4.1 Trade Route Descriptions

TR#	From	To	Weather Dependent Alternatives
4	Japan	Balboa	South to about 30N-35N in winter depending on intensity of lows moving from Japan vs. speed/stability of vessel. In summer routes up to and including Great Circle tracks. Courses in Eastern Pacific (Fall-Spring) also dependent on existence on "cut-off" lows north of Hawaii and Gulf of Tehuantepec gales.
5	U.S. East Coast	North Europe	Track and intensity of lows dictate a northerly or southerly route; also dependent on location of Azores high and on location of Ice Pack/Bergs in winter.
6	North Europe	U.S. East Coast	Route dependent on track of lows; east to east-northeast indicates a course via north of the U.K. with considerable distance/time savings Lows tracking to Greenland/Iceland would dictate a track via the English Channel.
7	U.S. East Coast	Mediterranean	Southerly or northerly routes dictated by track and intensity of lows and location of Azores high.
8	Mediterranean	U.S. East Coast	Southerly or northerly routes dictated by track and intensity of lows and location of Azores high.

Figure 4.1 Trade Route Descriptions (Continued)

TR#	From	To	Weather Dependent Alternatives
9	U.S. Gulf	North Europe	Track and intensity of lows dictate northerly or southerly routes; also location of Azores high and location Ice Pack/Bergs in winter. In addition, the use of the Gulf Stream current to best advantage through satellite updates.
10	North Europe	U.S. Gulf	Route north of U.K. when lows track east-northeast across Atlantic and via English Channel when lows track to Greenland/Iceland. In addition use satellite updates to minimize adverse Gulf Stream current.
11	U.S. Gulf	Mediterranean	Again, the track of the lows across the Atlantic and the location of the Azores high dictates a northern or southerly track. Also, satellite updates maximize Gulf Stream in Western Atlantic and minimize adverse effects of the North Equatorial current in the Eastern Atlantic.
12	Mediterranean	U.S. Gulf	The track of lows across the Atlantic and the Azores high are once again the determining factors. In this direction maximize the North Equatorial current and minimize the effects of the Gulf Stream.

Figure 4.1 Trade Route Descriptions (Continued)

TR#	From	To	Weather Dependent Alternatives
13	Persian Gulf	North Europe	Major decision involves whether to route east or west of Madagascar Dependent on tropical cyclone activity in the Mozambique Channel area or east of Madagascar. Routing also dependent to a lesser degree on strength and location of major current systems.
14	North Europe	Persian Gulf	Route east or west of Madagascar depending on tropical storms. Also dependent on strength and location of major currents.
15	Persian Gulf	Caribbean	East or west of Madagascar depending on tropical storms. Current location and strength is prime concern. Also dependent on presence of tropical storm activity in the Caribbean/Western Atlantic.
16	Caribbean	Persian Gulf	Tropical storms east or west of Madagascar, location and strength currents and presence of tropical storms in Caribbean and Western Atlantic all are factors to be considered.
17	Persian Gulf	North Atlantic	Tropical storm activity east or west of Madagascar and current strength and location as with previous Persian Gulf routes. Also, route across North Atlantic dependent on lows moving off U.S./ Canada.

Figure 4.1 Trade Route Descriptions (Continued)

TR#	From	To	Weather Dependent Alternatives
18	North Atlantic	Persian Gulf	Route from North Atlantic dependent on track of lows moving off U.S./ Canada. Again, current strength and location and tropical storm activity east or west of Madagascar must be considered.
19	Persian Gulf	Japan	Dependent on strength and location of tropical storms and monsoons in Arabian Sea, Bay of Bengal, South China Sea, and Philippine Sea.
20	Japan	Persian Gulf	Route dependent on location and strength of tropical storms and monsoons in Philippine Sea, South China Sea, Bay of Bengal, and Arabic Sea.
21	South East Asia	U.S. West Coast	Route north or south of Philippines dependent on presence of tropical storms and monsoons in Philippine Sea. Route across the North Pacific dependent on track and intensity of lows moving off Japan.
22	U.S. West Coast	South East Asia	Route across the North Pacific dependent on track and intensity of lows moving off Japan. North or south of Philipines dependent on presence of tropical storms and monsoons in the Philippine Sea.

Figure 4.1 Trade Route Descriptions (Continued)

Using the Ocean Routes, Inc., ship data file, average time savings that accrued to routed vessels over unrouted vessels on these major trade routes were assigned. The time savings were then increased by 10 percent to allow for improved performance given the more perfect weather information such as SEASAT would provide. These hourly savings for each trade route are shown in Figure 4.2, Hours Saved Per Voyage by Trade Route. As a general rule, routes which go north-south and/or stay close to land masses (e.g., Persian Gulf to North Europe) save less time than east-west routes which are crossing open water.

A further comment on why ships running near shore or those running north-south are unlikely candidates for avoiding storms and saving time even with better weather information should be made. An important factor in avoiding a storm is seeing the system in advance and then taking a diversionary course. When near land, manuveurability is restricted because of the landmass itself.
Further, storm systems move from west to east around the earth, and, therefore, if a ship is going in any east-west direction in open water, it will most likely have the chance to avoid a storm or at least its center if it can see the system far enough in advance. To avoid a system when moving north-south, it is necessary to stop completely or slow down and let the storm pass through the area ahead. Since a majority of travel along major land masses is in a north-

Route No.	Description	Hours Saved*
01	California to Japan	10.5
02	Japan to California	5.2
03	Balboa to Japan	5.8
04	Japan to Balboa	13.8
05	U.S. East Coast to North Europe	3.8
06	North Europe to U.S. East Coast	5.2
07	U.S. East Coast to Mediterranean	4.4
08	Mediterranean to U.S. East Coast	7.7
09	U.S. Gulf to North Europe	6.0
10	North Europe to U.S. Gulf	3.0
11	U.S. Gulf to Mediterranean	1.4
12	Mediterranean to U.S. Gulf	1.6
13	Persian Gulf to North Europe	1.0
14	North Europe to Persian Gulf	1.0
15	Persian Gulf to Caribbean	1.2
16	Caribbean to Persian Gulf	1.3
17	Persian Gulf to North Atlantic	2.3
18	North Atlantic to Persian Gulf	2.0
19	Persian Gulf to Japan	1.4
20	Japan to Persian Gulf	1.3
21	S.E. Asia to U.S. West Coast	4.6
22	U.S. West Coast to S.E. Asia	4.8

* These savings are 10 percent greater than the savings that ships experience which currently use weather routing. This assumes that the more perfect weather knowledge which SEASAT can provide would increase current savings by 10 percent.

Figure 4.2 Hours Saved Per Voyage by Trade Route south direction, it can be further seen why the option of going farther offshore to avoid a storm is not practicable.

Hourly operating costs for 10 tanker DWTs based on annual tanker operating costs in 1974 were calculated ("TAPS SEALEG STUDY," by Ocean Data Systems, 1974). These hourly costs, which were based on a 360-day year and exclude fuel and amortization costs, are shown in Figure 4.3, Tanker Operating Costs Per Hour. Operating Costs as opposed to vessel profitability are used because they are much easier to measure for any given ship. Profit involves extraneous variables that will vary considerably from one ship to another or even one voyage to another.

Figure 4.4, Average Dollars Saved Per Voyage by Vessels Having More Perfect Weather Information, puts together the hours and costs calculated in Figures 4.2 and 4.3 to show the average savings per voyage by trade route and vessel size. Based on the experience of Ocean Routes, it was assumed that approximately the same hourly savings per voyage would accrue to any of the vessel DWT's shown with speeds between 13 and 17 knots.

Because the price of fuel is such a large part of operating costs and because its costs have increased greatly since 1974, a separate table was made showing average tons of fuel consumed per hour by vessel size (Figure 4.5, Average Tons of Fuel Per Hour by DWT Group). The bunker cost

Vessel DWT	Cost/Hour* ($)
40,000	190
45,000	193
60,000	202
70,000	206
75,000	212
80,000	215
90,000	219
120,000	282
250,000	344
300,000	397

* From 1974 Ocean Data Systems Report calculating hourly costs from annual costs, assuming a 360-day year, excluding amortization.

Figure 4.3 Tanker Operating Costs Per Hour

savings per voyage will vary, depending on average consumption per hour (a function of horsepower and speed - see Figure 32, Normal Shaft Horsepower) and the costs per long ton. By using the tables provided, the dollar savings on any of the twenty-two trade routes for any of the ten vessel sizes can be calculated in the same manner as the example that follows.

VESSEL DWT	ROUTE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
40,000	2000	990	1100	2620	720	990	840	1460	1140	570	270	300	190	190	230	250	440	380	270	250	870	910
45,000	2030	1000	1120	2660	730	1000	850	1490	1160	580	270	310	190	190	230	250	440	390	270	250	890	930
60,000	2120	1050	1170	2790	770	1050	890	1560	1210	610	280	320	200	200	240	260	460	400	280	260	930	970
70,000	2160	1070	1190	2840	780	1070	910	1590	1240	620	290	330	210	210	250	270	470	410	290	270	950	990
75,000	2230	1100	1230	2930	810	1100	930	1630	1270	640	300	340	210	210	250	280	490	420	300	280	980	1020
80,000	2260	1120	1250	2970	820	1120	950	1660	1290	640	300	340	220	220	260	280	490	430	300	280	990	1030
90,000	2300	1140	1270	3020	830	1140	960	1690	1310	660	310	350	220	220	260	280	500	440	310	280	1010	1050
120,000	2960	1470	1640	3890	1070	1470	1240	2170	1690	850	390	450	280	280	340	370	650	560	390	370	1300	1350
250,000	3610	1790	2000	4750	1310	1790	1510	2650	2060	1030	480	550	340	340	410	450	790	690	480	450	1580	1650
300,000	4170	2060	2300	5480	1510	2060	1750	3060	2380	1190	560	640	400	400	480	520	910	790	560	520	1830	1910
VOYAGES/ YEAR**	12.1		7.3		17.6		17.0		12.4		12.8		5.1		5.6		4.9		8.7		7.5	

* Assumes that the hours saved will be the same for all DWT's and all speeds between 13 and 17 knots.

** Based on 320 sea days and an average speed of 15 knots.

Figure 4.4 Average Dollars Saved Per Voyage* (Excluding Fuel Costs)

DWT Range (000)	Average Consumption*
20-29	1.85
30-49	3.00
50-69	3.15
70-99	3.17
100-199	3.92
200-239	5.98
240+	6.75

*Based on sample consumption rates for 15 to 16 knot tankers.

Source: 1974 Tanker Register; H. Clarkson, London.

Figure 4.5 Average Tons of Fuel Consumed Per Hour by DWT.

4.3 Estimation of Benefits

To demonstrate how the savings per voyage on any of the twenty-two trade routes can be calculated, the following example is used as an illustration:

Trade Route......................#3

Vessel Speed.....................16 knots

Vessel DWT.......................120,000 tons

Bunker Cost/Ton..................$70.00

Shaft Horsepower$_{normal}$............ 24,000.

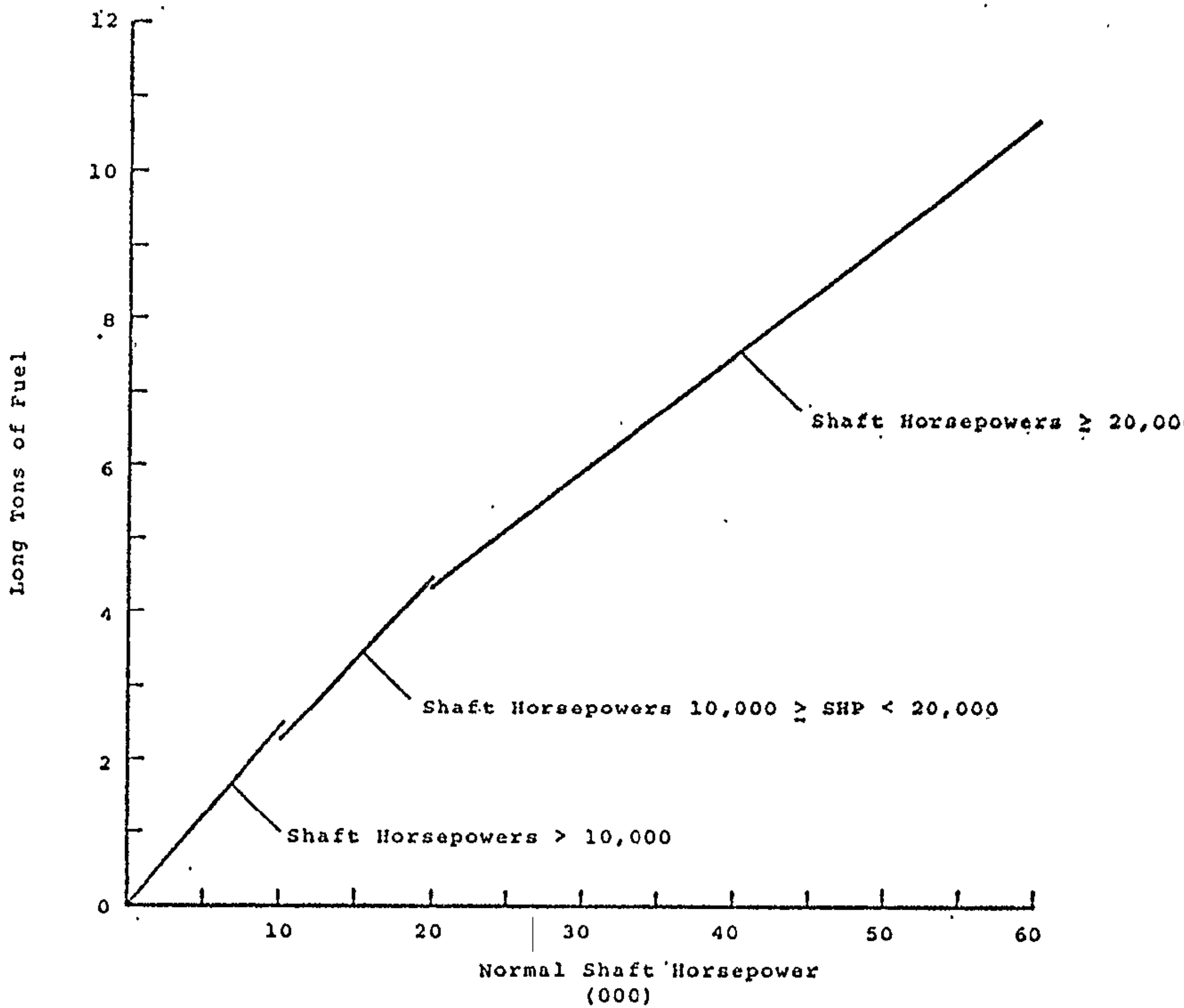

Figure 4.6 Normal Shaft Horsepower vs. Long Tons of Fuel Consumed Per Hour

If Shaft Horsepower$_{normal}$ (SHP_N) is unknown, a rough approximation can be made using the following equation:

$$SHP_n = .0015 * \Delta^{.45} V^4 \quad \text{Where } \Delta = \text{Displacement} = DWT * 1.28$$
$$V = \text{Speed.}$$

The average cost savings in trade route #3 for a 120,000 DWT vessel is $1,640 excluding fuel savings as found in Figure 30. To find the fuel savings, go to Figure 4.6, and find that a 24,000 SHP_N vessel (running at full power) burns 5 tons of fuel per hour. At $70.00 per ton, this figures out to be a savings of $2,030 for fuel and a total voyage savings of $3,670.

If the SHP_N for this example had been known, then going through the horsepower estimation would have given a SHP of 21,200.

4.3.1 Estimation of Savings on All Routes

The figures presented in Figure 4.7, Sample Ship Trade Route Assignments, constitute a random sample of vessels assigned to major tanker trade routes at the beginning of 1975. They account for 12.6 percent or approximately one-eighth of the tanker fleet greater than 20,000 DWT assigned to major world tanker trade routes. Ships operating on U.S. Intercoastal routes, Inter-Mediterranean routes, and Mediterranean-North Europe routes are excluded from the total population size.

VESSEL DWT	TOTAL	TRADE ROUTE NUMBER											
(000)	BY SIZE	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	TOTAL
20-29	485	7	4	7	6	12	5	4			13	2	60
30-49	748	6	2	5	9	8	18	8	10	5	20	4	95
50-69	401		2	3	6	1	4	4	8	6	14	2	50
70-99	421	4	5	1	2	1		10	2	16	11	3	55
100-199	327	1			1	2		19	1	1	12	3	40
200-239	241							20	2		8		30
240+	144							13	3	1	3		20
TOTAL	2767	18	13	16	24	24	27	78	26	29	81	14	350

Note: This sample is 12.6% of 1974 tanker population (those tankers on major world tanker trade routes). Total 1974 population - 2767 vessels (excludes all vessels less than 20,000 DWT and 1/3 of vessels between 20,000 and 30,000 DWT).

Routing Source: Lloyd's Voyage Record
Various Issues, January-April 1975

Figure 4.7 Sample Ship Trade Route Assignments, First Quarter 1975

To find the potential savings for each trade route by ship size, calculations are as follows (using route numbers 1-2 and ships between 70,000 and 99,999 DWT tons as an example).

Figure 4.4 shows that each ship can make up to 12.1 voyages per year on this route if it is exclusively assigned to this route for the entire year. From Figure 4.7, four ships of this size were assigned to trade routes 1-2. By multiplying these figures together and then multiplying by 8 (as the sample is approximately one-eighth of the total population) a potential of 387 round trip voyages per year is obtained. Using 80,000 DWT as the average vessel size for the 70,000 to 99,999 DWT group, a savings of $3,380 per round trip voyage (excluding fuel) is realized. Multiplying this by the 387 voyages gives an annual savings of $1,308,000. To calculate fuel savings, Figure 4.2 shows that 15.7 hours per round trip are saved. Multiplying this by $70.00 per ton of fuel and 3.17 tons of fuel consumed per hour (Figure 31) and finally multiplying once again by the 387 potential voyages yields a fuel savings of $1,348,000 per year and total annual savings of $2,656,000. Figure 4.8 shows the calculation for each trade route and vessel DWT size.

The total savings is almost $69,000,000 based on the 1974 fleet of almost 2,800 tankers.

DWT		TRADE ROUTE NUMBERS 1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	TOTAL
20-29	Op Cost	2026	869	1685	1877	2036	292	62			470	214	9531
	Fuel	1378	592	1149	1279	1387	199	42			316	146	6488
	Total	3404	1461	2834	3156	3423	491	104			786	360	16019
30-49	Op Cost	1736	434	1204	2815	1357	1051	124	215	161	724	427	10248
	Fuel	1915	481	1331	3110	1500	1161	137	235	177	789	474	11310
	Total	3651	915	2535	5925	2857	2212	261	450	338	1513	901	21558
50-69	Op Cost		463	769	1999	181	246	65	179	202	526	228	4858
	Fuel		505	838	2177	197	271	72	198	223	580	249	5310
	Total		968	1607	4176	378	517	137	377	425	1106	477	10168
70-99	Op Cost	1309	1232	273	710	191		180	48	577	444	364	5328
	Fuel	1348	1270	281	730	198		181	50	598	459	375	5490
	Total	2657	2502	554	1440	389		361	98	1175	903	739	10818
100-199	Op Cost	429			464	504		434	32	47	635	477	3022
	Fuel	417			452	490		425	31	46	619	464	2944
	Total	846			916	994		859	63	93	1254	941	5966
200-239	Op Cost							555	77		518		1150
	Fuel							683	94		629		1406
	Total							1238	171		1147		2556
240+	Op Cost							424	134	67	226		851
	Fuel							501	159	80	266		1006
	Total							925	293	147	492		1857
TOTAL	Op Cost	5500	2998	3931	7865	4269	1589	1844	685	1054	3543	1710	34988
	Fuel	5058	2848	3599	7748	3772	1631	2041	767	1124	3658	1708	33954
	Total	10558	5846	7530	15613	8041	3220	3885	1452	2178	7201	3418	68942

Figure 4.8 Total Annual Savings by Trade Route and Vessel Size ($000's)

Most estimates for the number of ships greater than 6,000 DWT that will be in the 1985 tanker fleet range between 4,500 and 5,000 ships. The larger vessels operating on the longer trade routes from the Persian Gulf will make about five-and-a-half (5-1/2) round trips per year, while others operating on shorter trade routes will make 12 round trips per year. If it is assumed that 80 percent of the 5,000 tankers operate on major trade routes, save on the average of 8 hours per round trip, make an estimated 8 round trips per year, and on the average cost $400 per hour (fuel included) to operate, a total annual savings of $102,000,000 is realized. A lower limit savings would be 3,000 ships making 7 round trips per year, saving 5 hours per round trip, costing $300 per hour for a total annual savings of $31,500,000.

4.3.2 Loss Prevention

Loss prevention deals with possible savings that can be realized by avoiding catastrophic or partial losses due to weather-related conditions.

Lloyd's casualty returns for 1973 contain two examples of weather-related losses for tankers in that year (see Figure 35, Vessels Lost or Damaged by Weather Conditions). There were a large number of losses for small coastal vessels, but it was felt that these were not representative of the losses tankers would incur. In addition, in almost all cases, vessels operating in coastal waters,

Vessel Name	Flag	DWT Tons	Year Built	From-To
NAPIER (Tanker)	Liberia	38561	1959	Africa-Rio de Janeiro
Ran aground in heavy weather, LAT 44.45S LONG 75.05W on June 9, 1973. Subsequently broke in two and was set on fire to avoid oil pollution.				
AARON (Tanker)	Panama	16000	1951	Hilo-Yokohama
Broke in two and sank in heavy weather, LAT 33N LONG 165E on September 2, 1971.				
IZ (Tanker)	Yugoslavia	21409	1960	Puerto La Cruz-Faeringhaven
Stuck in ice, LAT 49.05N LONG 51.00W on April 5, 1973. Repaired in New York and sailed.				
SOFIA P.	Liberia	19000	1954	Balboa-Singapore
Sank in heavy seas, LAT 31N LONG 151E on January 5, 1970.				
CHRYSSI	Panama	31000	1953	Pacific Northwest Japan
Broke in two and sank in heavy weather, LAT 31N LONG 71W on December 26, 1970.				
TEXACO OKLAHOMA	United States	35000	1958	
Broke in two and sank in heavy seas, LAT 36N LONG 74W, on March 27, 19				
RAGNY	Finland	17000	1951	
Broke in two and sank in heavy seas, LAT 38N LONG 61W on December 27, 1970.				

Figure 4.9 Vessels Lost or Damaged by Weather Conditions

regardless of size, cannot avoid loss from weather by using better weather information. The only way they could avoid a loss is to choose not to sail if that option is open to them.

By using the Ocean Routes, Inc., historical ship data file, the two voyages were recreated up to the time of the loss, and then determination was made if the loss could have been prevented if the ship had been weather routed.

Because of the low number of casualties in 1973, five additional examples were chosen from the tanker advisory center report, "A Study of Total Tanker Losses 1964-1973." Although they stated there were 22 weather losses in this time period, they gave details on only ten of the losses. Because of the available information, only the five casualties that occurred in 1970 or later were examined.

The NAPIER was lost in coastal waters off Chile while sailing south towards the Strait of Magellan. The vessel could not have avoided the heavy weather conditions that caused its sinking if it had been under weather routing.

The AARON was on the shortest route between Hawaii and Japan. This course took the ship directly into the south-east quadrant of an intense low pressure system (formerly Typhoon Trix). The conditions were 25-foot seas and winds of more than 50 miles per hour. If the ship had been weather routed, it would have been diverted south where seas were between 5 and 10 feet and the winds between 5 and 15 miles per hour. In this case, it can be clearly concluded that the ship would not have been lost if it had been weather routed.

The IZ got stuck in the Ice Pack and sustained hull damage. With good information on the Ice Pack, the IZ could have taken a more southerly route, avoided the ice, and sustained no damage. The IZ sustained its damage during April and followed the more northerly course because the Ice Pack is generally farther north by this time of the year.

The SOFIA P. was on a direct course to Singapore from Balboa. This course took her directly into a storm with 35-40 knot winds, 20-25 foot seas and severe swells and a cross-sea sea condition. A slight diversion would have avoided this combination of conditions that led to the sinking of the vessel.

The CHRYSSI, TEXACO OKLAHOMA, and RAGNY were all lost while sailing in coastal regions and would not have been aided by weather routing.

Of the seven examples of weather losses, three could have been prevented by weather routing. Of the three, the IZ and the SOFIA P. would have been aided by the better information SEASAT will provide. The AARON should have been able to avoid the storm system with technology available today.

From this information, a rough estimate can be made of the range of weather-related losses which could be prevented with weather routing. If the three ships mentioned could have been aided (and the total sample is 24 [2 vessels from 1973 Lloyd's and 22 vessels from the Tanker Advisory Center Report]) then the lower limit is twelve percent. However, if the pattern of helping 2 out of every 5 vessels were feasible (as with the Tanker Advisory Center Report sample) then the upper limit is forty percent.

Coast Guard data for the period from January 1, 1970, through June 30, 1974, show that the 103 out of 350 weather-caused incidents occurred in open water. This is approximately 30 percent, which further supports the 12 to 40 percent range. The Coast Guard data, however, were too incomplete to draw any further conclusions as to whether a routing service could have prevented the damage the vessels incurred.

The dollar savings that can be attributed to the three ships are as follows:

IZ		50-100k in damages
AARON	6.4m*	Undepreciated Replacement Cost
SOFIA P..	7.6m*	Undepreciated Replacement Cost.

Every ship loss involves a multi-million dollar economic loss plus the probable loss of human life. The examples cited show that, with today's weather forecasting technology, there are still catastrophic losses. While many losses are due to human error, more accurate weather forecasting will reduce the number and extent of such losses.

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* Assumes construction costs of $400 per ton for ships of this size.

4.3.3 Tanker Loss Trends

A review of casualty statistics from recent international conferences on Ocean Hull Casualties was conducted to determine (1) the trends in tanker loss ratios, (2) if ship age is a factor in weather vulnerability, and (3) if age is a definite factor in loss, and to assign a dollar value to VLCC and ULCC losses in the 1980-1985 time frame when these ships will be ten years old or older.

After reviewing several papers, it became evident that tanker loss ratios have been steadily increasing since 1959. The percentages of tonnage of lost tankers out of the total world tanker fleet averaged .19 percent in the 1959-1963 time period, period, rose to .29 percent in the 1964-1968 time period, and climbed to .37 percent in the 1969-1973 time frame (International Union of Marine Insurance, Berlin Conference 1974, Casualty Statistics - Ocean Hulls). It is also evident that vessel losses in general for all causes increase with age. This trend holds true for tankers, with the exception that, after a tanker reaches 25 years of age, the loss ratio drops dramatically. This can be explained by the fact that most tankers of that age are jumboised and rebuilt T-2's and thus virtually newly built ships (International Union of Marine Insurance, Venice Conference 1973, Casualty Statistics - Ocean Hulls, Prepared and remarks by Peter Quaile).

To summarize, listed here are significant findings and assertions that have been presented at recent casualty conferences and in current papers on tankers.

1. Age makes a ship more vulnerable to structural failure (one of the most common weather-related problems).

2. Statistics show smaller ships of all types and ages are more susceptible to weather loss or damage.

3. Larger tankers (greater than 80,000 DWT) are safer than smaller tankers (they can transport oil over a given distance seven times safer than a ship less than 80,000 DWT) - but it should be remembered that the majority of larger tankers are still relatively new, five years of age or less; consequently, no historical loss information due to the aging of these ships exists ("Tankers and U.S. Energy Situation: An Economic and Environmental Analysis," Joseph A. Porricelli and Virgil F. Keith, Marine Technology, October 1974).

4. The critical age for structural failure on tankers occurs at twelve years, which might tend to make a recertification and thorough inspection at this age prudent (Porricelli and Keith).

5. A paper prepared by Peter Quaile for the 1973 International Union of Marine Insurance Conference has tried to draw the conclusion that, based on the increasing loss ratio of aging tankers of today (smaller tankers), one should possibly expect that, as supertankers age, their loss experience will also increase. (This may be invalid based on the other facts presented in Items 2, 3, and 4 above).

4.3.4 VLCC and ULCC Loss Projection

From this information, it appears that VLCC's and ULCC's will experience some greater loss than they do today, but not as great a loss ratio as today's older and smaller tankers. Close structural checks along with optimal weather knowledge might be the necessary tools to keep the loss ratio for VLCC's and ULCC's low when they reach 12 years of age or greater.

If one wishes to put a dollar figure on 1980-1985 VLCC and ULCC losses without taking the above steps to help prevent loss, a good estimate might be to apply the 1969-1973 average tanker loss ratio (the total of both actual and constructive losses) of .37 percent to the forecasted VLCC and ULCC tonnage for those five years (International Union of Marine Insurance, Berlin Conference, 1974, Casualty Statistics - Ocean Hulls). For the loss ratio for tankers, the fact that weather-related losses accounted for about 20 percent of total tanker losses between 1968 and 1972 was considered (International Union of Marine Insurance, Venice Conference, 1973, Casualty Statistics - Ocean Hulls). The total DWT tons of VLCC's and ULCC's (vessels over 200,000 DWT) operating as of December 31, 1972, was 66,400,000 (World Tanker Ship Fleet Inventory - Sun Oil). Between January 1, 1973, and January 1, 1975, an additional 50,600,000 DWT tons were delivered (Fairplay International Shipping Journal - "World Ships on Order," Quarterly Supplements: May, August, and November 1973; May, August, and November 1974; February 1975). As of February 1, 1975, there were under construction or contract an additional 128,900,000 DWT tons of VLCC and ULCC capacity. In addition, 53,800,000 DWT tons were in a contract pending or negotiating stage (Fairplay - "World Ships on Order," Quarterly Supplement, February 20, 1975). If it is assumed that all this tonnage is built and no other subsequent tonnage is ordered, there will be a total of 299,700,000 VLCC and ULCC tons in the 1980-1985 period. Given the current depression in the world tanker market and the recent high cancellation rate, it is unreasonable to assume all tonnage now under contract or being negotiated will be built. However, to try to predict the tanker demand two or three years hence is also a difficult task, and there may very well be a new wave of VLCC and ULCC orders prior to 1985.

Therefore, given the variable conditions, the total of 299,700,000 DWT tons should be a reasonable estimate of the total VLCC and ULCC DWT tons in the 1980-1985 time frame. If $170.00 per DWT ton (1974 dollars) is taken as an average construction cost for VLCC's and ULCC's, times the total DWT in service, an investment of $51,000,000,000 is derived. By applying 20 percent of the loss ratio factor of .37 percent (to account for weather loss only) to the total investment, $37,700,000 is the average undepreciated cost per year to replace lost tonnage (1974 dollars) if the 1969-1973 tanker loss ratio applies to VLCC's and ULCC's in the 1980-1985 time frame. The approximate cost of one 200,000 DWT tanker at 1974 costs is $37,700,000. To get the total loss for the period mid-1980 to mid-1985, take 5 times $37,700,000, which yields $185,000,000. This figure does not take into consideration the costs for cargo loss, environmental damage and clean-up, loss of life, or vessel losses that are less than total losses.

One further modification to these costs is required. As shown in the previous section, weather-related losses that occur in areas where they could have been prevented (noncoastal waters) account for 12 to 40 percent of total weather losses.

Therefore, the total dollars that could be saved by preventing weather losses ranges from $22,200,000 to $74,000,000 over the five year period, or $4,440,000 to $14,800,000 per year in the 1980-1985 period.

4.4 Generalization of the Results, Tankers

Using the results of the tanker case study immediately above and the forecasts of Section 2.2.3, the Results Global Forecasts, the incremental benefits of SEASAT for tanker operations in the 1985-2000 time period are presented in this section. It is also necessary to shift the value unit from 1974 dollars to 1975 dollars. The case study was done in 1974 dollars since the majority of data were collected in this unit and it is easier to adjust the final benefit figure to 1975 dollars rather than all input figures.

The results of the case study above found the benefits from:

I. Time savings - through avoidance of adverse weather

All routing benefits in 1985

$102,000,000 (in 1974 dollars) - Upper limit

Portion due to SEASAT

10%	15%
$10,200,000	$15,300,000

$ 35,500,000 (in 1974 dollars) - Lower limit

Portion due to SEASAT

10%	15%
$ 3,150,000	$ 4,725,000

II. Prevention of catastrophic losses - through avoidance of adverse weather

All routing benefits in 1983

$37,700,000 (in 1974 dollars)

Portion due to SEASAT

12%	40%
$4,524,000	$15,080,000.

The global forecasts of Section 2.2.3 indicate growth in active gross tonnage of tankers of 8.7% through the 1985-2000 time period. The benefits were adjusted to 1975 dollars by using a 9% inflation factor (a weighted factor of relevant U.S. price indexes from the Survey of Current Business). Using the benefit figures of a 8.7% growth rate and the 9% inflation factor, the final generalized benefits for the 1985-2000 time period were calculated and the benefits are presented in Figure 4.10, Generalization Results-SEASAT Benefits to Tanker Operations, 1985-2000.

I. Benefits from Time Savings - millions of $ (1975)				
	Upper Limit All Routing Benefits Due to SEASAT		Lower Limit All Routing Benefits Due to SEASAT	
	High (15%)	Low (10%)	High (15%)	Low (10%)
1985 (Undiscounted)	$16.7	11.1	5.2	3.4
1985-2000 (Discounted*)	94.3	62.8	29.1	19.4

II. Benefits from Prevention of Catastrophic Losses - millions of $ (1975)		
	Due to SEASAT	
	High (40%)	Low (12%)
1985 (Undiscounted)	19.4	5.8
1985-2000 (Discounted*)	109.8	32.9

*Discount Rate - 10%

Figure 4.10 Generalization Results-SEASAT Benefits to Tanker Operations, 1985-2000 (in million 1975 dollars)

5. CANADIAN STUDY RESULTS

The Canadian Center for Remote Sensing (CCRS) has conducted an economic assessment of Canadian applications of SEASAT data. Among the areas assessed are weather routing possibilities and reduction in marine insurance costs through casualty avoidance. The CCRS has worked closely with NASA and ECON in this assessment, and the results to date of the Canadian effort in these areas, although not yet complete, are summarized in this section.

The Canadian study of routing focuses on Canadian international cargo, i.e., cargo loaded or unloaded at Canadian ports and destined for or emanating out of an ocean crossing. As a basis for estimating potential savings in Pacific crossings attributed to the use of SEASAT type data, some simplifying assumptions are required. First, it is assumed that the ratio of cargo tonnage to net tonnage of a typical ship is 1/1, or cargo tonnage to gross tonnage is 0.5/1. Then it is assumed that a typical ship bound from Vancouver to ports in Europe, the Middle East, Africa, Asia, and Oceania is 10,000 tons net, carries a cargo of 10,000 tons, has a rated speed of 17 knots and an operating cost of $13,000 per day (1974 dollars). The defined "typical" ship is a useful proxy to represent the complicated distribution of ship sizes, types, and costs.

Assuming that routing services will be available to all ships at the time SEASAT operational systems become available, the Pacific westbound crossings of interest would be in the range of 9 to 13 days for freighters and bulk carriers bound from Vancouver to Japan, and longer from Vancouver to other ports in Europe, the Middle East, Africa, Asia and Oceania. For purposes of analysis, a typical crossing is assumed to take 11 days.

As in the case of the Pacific shipping analysis, it is assumed that the ratio of cargo tonnage to net tonnage of a typical ship is 1/1, or cargo tonnage to gross tonnage is 0.5/1.0. Then it is assumed that a typical ship bound from Atlantic ports to ports in Europe, the Middle East, Africa, Asia, and Oceania is 12,000 tons net, carries a cargo of 12,000 tons, and has a rated speed of 17 knots and an operating cost of $13,000 per day (1974 dollars).

Assuming that routing services will be available to all ships at the time SEASAT operational systems become available, the Atlantic eastbound crossings of interest would be in the range of 7 to 10 days from U.S. east coast ports to northern Europe. The crossings of interest would be in the range of 7 to 12 days from Canadian Atlantic ports to northern Europe and the Mediterranean. For purposes of analysis, a typical crossing is assumed to take 8 days. This is a conservative assumption.

Benefits are calculated from the figures and ship routing study results calculated at ECON.

Forecasts of Canadian international trade at Canadian Atlantic, Pacific, and Great Lakes ports to the year 2000 resulted in benefits which are given in Figure 37, Canadian International Trade SEASAT Benefits. This trade includes both arrivals and departures of cargo unloaded or loaded at Canadian ports in 1974 dollars. The most recent trade history of Canada indicates a 5.2% growth rate, which is called Scenario A. A lower limit for growth of trade is 3%, which is called Scenario B.

In the area of marine insurance, the CCRS approached the study from the financial side as opposed to the real side as done by ECON in the U.S. dry cargo and World tanker fleet portions of this study. In 1973, about 27 percent of operating expenses for Canadian water transportation companies were related to ocean going shipping, and about 41 percent were related to Atlantic and Pacific coastal shipping (domestic and international). It is estimated that 40 to 50 percent of the operating expenses of these Canadian companies are related to international ocean going and coastal trade (Atlantic and Pacific). On this basis, it is estimated that between $5 million and $10 million of 1973 Canadian shipping insurance expenses, or between $4 million and $8 million of claims paid, was related to international ocean going and coastal trade.

		Pacific	Atlantic	Great Lakes	Totals
1980	Scenario A	$3.5 mil.	3.0	0.3	6.8
	Scenario B	2.8	2.6	0.2	5.6
1990	Scenario A	6.3	5.4	0.5	12.2
	Scenario B	3.7	3.3	0.3	7.3
2000	Scenario A	11.5	9.7	0.7	21.9
	Scenario B	5.0	4.5	0.4	9.9

Figure 5.1 Canadian International Trade, SEASAT Benefits 1980-2000 in 1974 Dollars

Most of Canada's international imports and exports are carried by foreign vessels. For example, in 1972 foreign vessels accounted for about 141 million tons and Canadian vessels about 20 million tons of cargoes arriving and departing Canadian Atlantic and Pacific ports in international trade. Thus, foreign vessels carried 7 times as much as Canadian vessels in this category. It seems reasonable to assume, therefore, that operating expenses of all vessels engaged in this Canadian trade are 5 to 10 times as great as Canadian expenses and that insurance expenses and claims paid are in the same proportions. On this basis, total insurance claims would range from $20 million to $80 million per year (1972).

Assuming shipping growth rates approximately as in the above (Scenarios A and B applied between 1972 and 2000 A.D.), assuming a constant Canadian share of the total, and assuming constant insurance rates, one obtains the following forecast of insurance claims paid in connection with international shipping to and from Canadian ports.

Range of Estimated Insurance Claims (10^6 Dollars, 1974)

	Scenario A		Scenario B	
Year	Canadian	All Firms	Canadian	All Firms
1972*	5-9	25-90	5-9	25-90
1978+	6-11	30-110	6-11	30-107
1980	7-13	35-130	6-11	32-115
1990	13-23	65-230	9-15	43-153
2000	23-40	115-400	11-21	57-206

At the present time, it is not known what impact SEASAT will have in reducing ship damages and sinkings; hence insurance claims and finally ship insurance expenses. For purposes of parametric analysis, potential savings of 10 and 20 percent are postulated. Such potential savings seem feasible in view of the estimate that "Grounding and collision account for over 50 percent of all ship losses and oil spills," and the following data:

Shipping Damages Cause, 1956-1970	% Loss of Shipping	% of Oil Spill Caused
Grounding	43.6	48.4
Foundering	18.0	5.6
Hull Failure	2.0	27.0
Fire-explosion	15.3	1.0
Collision	12.0	6.7
Contact damage	4.5	0.5
Machinery	1.2	-
Missing	1.9	-
Other	1.5	3.0
Total	100.0	100.0

Groundings, foundering, hull failure, and collisions are largely related to bad weather conditions and heavy seas, and partly to ship design faults. SEASAT data may be useful in these cases.

The figure, Figure 5.2, Range of Benefits of SEASAT Related to Insurance Claims, shows potential ranges of benefits of SEASAT data in reducing damages. The estimates are based on the hypothetical 10 percent and 20 percent savings.

The Canadian study calculates benefits to SEASAT from routing beginning with the launch of SEASAT-B in 1978. To present the Canadian results in a manner consistent with the other figures in this study, only benefits in the 1985-2000 time frame are considered in the overall results below. The fully operational SEASAT is expected to be launched in 1985 although the interim SEASAT systems preceeding the operational system may generate substantive benefit beginning in 1978.

Potential Million Dollars Per Annun (1974 Dollars)

	1980	1990	2000
SCENARIO A			
10 percent savings			
Canadian Firms	0.7-1.3	1-2	2-4
All Firms	3.5-13.0	7-23	12-40
SCENARIO A			
20 percent savings			
Canadian Firms	1.4-2.6	2-4	4-8
All Firms	7.0-26.0	14-46	24-80
SCENARIO B			
10 percent savings			
Canadian Firms	0.6-1.1	1-2	1-2
All Firms	3.2-11.5	4-15	6-21
SCENARIO B			
20 percent savings			
Canadian Firms	1.2-2.2	2-3	2-4
All Firms	6.4-23.0	8-30	12-42

Figure 5.2 Range of Benefits of SEASAT Related to Insurance Claims (Damages), Shipping to and from Canadian Ports in Millions of 1974 Dollars

Two other adjustments were necessary to make these results consistent with the rest of the study. First, all results were shifted from 1974 dollars to 1975 dollars using a 9% inflation factor. And second, the Canadian study results were scaled down by 8.7% (the share of tankers in Canadian trade) to avoid double counting of benefits when the Canadian results are added into the U.S. dry cargo and the World tanker fleet figures.

After making these adjustments, the Canadian trade route benefits are estimated to be:

- $6.4 million to $9.2 million in 1985, undiscounted, for reduction in delay time due to adverse weather
- $25.2 million to $43.8 million, 1985-2000, cumulative discounted benefits, for reduction in delay time due to adverse weather
- $5.0 million to $34.9 million in 1985, undiscounted, for reduction in insurance costs due to fewer weather-related casualties
- $24.5 million to $163.6 million, 1985-2000, cumulative discounted benefits, for reduction in insurance costs due to fewer weather-related casualties.

6. OVERALL RESULTS

The results of the marine transportation study focused on the benefits to be derived from the use of SEASAT in ocean condition and weather forecasting. These forecasts are extensively used at present (as described in Section 2.3) to route ships to minimize time losses and damage from adverse weather. By improving this procedure, SEASAT can produce incremental benefits in the areas of direct operating costs and marine insurance costs. Specifically, the benefits come from:

- Reduction in delay time due to adverse weather
- Prevention of catastrophic losses due to adverse weather (total losses such as groundings or sinking)
- Reduction in hull casualties (damage to ship and ship equipment)
- Reduction in P & I and cargo casualties (injury to personnel, liability for casualty-related damage such as oil spills, and cargo damage).

Various aspects of ship routing have been examined in detail in this report for three major segments of world shipping:

- Dry cargo shipping on all U.S. trade routes
- Dry cargo shipping on Canadian trade routes
- World tanker fleet operations.

Complete assessment was not possible because of the lack of data, inaccessibility of existing data, and poor quality of data available. This is especially true of the marine

P & I and cargo insurance industries which are much less organized and clearly defined than the hull insurance industry.

The study was also restricted to ocean crossing shipping. Thus, coastal shipping and inland shipping were not included in this assessment. This was done because the weather routing procedure is a direct application of SEASAT data in the long-range (2 to 10 days) ocean condition forecasting operation, while coastal and inland shipping are "short-term, local" forecasting problems. SEASAT data will provide valuable data to the short-term, local weather forecasting operation, but it would be difficult to distinguish and properly quantify the incremental benefit due to SEASAT. Therefore, even though coastal and inland shipping are larger operations than ocean shipping and the benefits from SEASAT in this area may be very substantial, no attempt has been made to estimate these benefits in this study.

The benefits estimated in all areas of this study ·e are summaried in Figure 6.1, Overall Results, Benefits Due to SEASAT in Marine Transport, in 1975 Dollars.

		Dry Cargo				Tankers		Totals Estimated	
		All U.S. Trade Routes		Canadian Trade Routes		World Fleet, All Major Routes			
	Source of Benefits	1985 Undiscounted Benefits	1985-2000 Cumulative Discounted Benefits*	1985 Undiscounted Benefits	1985-2000 Cumulative Discounted Benefits*	1985 Undiscounted Benefits	1985-2000 Cumulative Discounted Benefits*	1985 Undiscounted Benefits	1985-2000 Cumulative Discounted Benefits*
Direct Operating Costs	Delay Time Cost Savings	20,660,000	86,620,000	6,440,000 to 9,220,000	25,200,000 to 43,800,000	3,430,000 to 16,680,000	19,400,000 to 94,250,000	30,530,000 to 46,560,000	131,220,000 to 224,670,000
Marine Insurance Costs	Prevention of Catastrophic Losses	(not estimated)		5,000,000 to 39,900,000	24,500,000 to 163,600,000	5,830,000 to 19,420,000	32,930,000 to 109,800,000	17,230,000 to 60,720,000	84,270,000 to 300,240,000
	Reduction in Casualty Costs (Hulls)	6,400,000	26,840,000			(not estimated)			
	Reduction in Casualty Costs (P&I cargo)	(not estimated)				(not estimated)			
	Totals Estimated	27,060,000	113,460,000	11,440,000 to 44,120,000	49,900,000 to 207,400,000	9,260,000 to 36;100,000	52,330,000 to 204,050,000	47,760,000 to 107,280,000	215,490,000 to 524,910,000

*Discount Rate - 10%

Figure 6.1 Overall Results, Benefits Due to SEASAT in Marine Transport, in 1975 Dollars

APPENDIX A

Aggregate Forecasts

of

Imports on U.S. Trade Routes, Dry Cargo

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities (Imports - in mil. lbs)				
	U.S. Atlantic Trade Routes			
Year	01	02	04	12
History				
1973	4,575	3,609	11,189	9,187
($ per lb.)	.114	.085	.280	.095
Forecast				
1985	12,505	4,899	39,815	22,143
1986	13,505	4,987	42,960	23,582
1987	14,586	5,077	46,354	25,115
1988	15,753	5,168	50,016	26,748
1989	17,013	5,261	53,967	28,486
1990	18,374	5,356	58,231	30,338
1991	19,844	5,452	62,831	32,310
1992	21,431	5,551	67,795	34,410
1993	23,146	5,650	73,151	36,647
1994	24,997	5,752	78,930	39,029
1995	26,997	5,856	85,165	41,565
1996	29,157	5,961	91,893	44,267
1997	31,490	6,068	99,153	47,145
1998	34,009	6,178	106,986	50,209
1999	36,730	6,289	115,437	53,473
2000	39,668	6,402	124,557	56,948
Growth Rate Forecast, 1973-2000	8.0%	1.8%	7.9%	6.5%

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

	U.S. North Atlantic Trade Routes			
Year	05	06	07	08
History				
1973	3,567	5,387	3,194	6,622
($ per lb.)	.243	.047	.223	.189
Forecast				
1985	6,696	11,017	6,411	12,859
1986	6,915	11,857	6,840	13,682
1987	7,141	12,699	7,299	14,558
1988	7,374	13,600	7,788	15,489
1989	7,615	14,566	8,310	16,481
1990	7,864	15,600	8,866	17,535
1991	8,120	16,708	9,460	18,658
1992	8,386	17,894	10,094	19,852
1993	8,660	19,165	10,771	21,122
1994	8,943	20,525	11,492	22,474
1995	9,235	21,983	12,262	23,912
1996	9,536	23,543	13,084	25,443
1997	9,848	25,215	13,960	27,071
1998	10,170	27,005	14,896	28,804
1999	10,502	28,923	15,894	30,647
2000	10,845	30,976	16,959	32,609
Growth Rate Forecast, 1973-2000	3.3%	7.1%	6.7%	6.4%

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. North Atlantic Trade Routes	
	09	10
History		
1973	3,067	8,381
($ per lb.)	.159	.305
Forecast		
1985	5,651	30,132
1986	5,996	32,844
1987	6,361	35,800
1988	6,749	39,022
1989	7,161	42,534
1990	7,598	46,362
1991	8,061	50,534
1992	8,553	55,082
1993	9,075	60,040
1994	9,629	65,443
1995	10,216	71,333
1996	10,839	77,753
1997	11,500	84,751
1998	12,202	92,379
1999	12,946	100,693
2000	13,736	109,755
Growth Rate Forecast, 1973-2000	6.1%	9.0%

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

	U.S. Atlantic Trade Routes		
Year	35	41	51
History			
1973	148	2,469	1,551
($ per lb.)	.052	.121	.237
Forecast			
1985	264	6,861	3,173
1986	276	7,355	3,335
1987	289	7,884	3,505
1988	302	8,452	3,684
1989	316	9,061	3,871
1990	331	9,713	4,069
1991	346	10,412	4,276
1992	362	11,162	4,495
1993	378	11,966	4,724
1994	396	12,827	4,965
1995	414	13,751	5,218
1996	433	14,741	5,484
1997	453	15,802	5,764
1998	474	16,940	6,058
1999	495	18,160	6,367
2000	518	19,467	6,691
Growth Rate Forecast, 1973-2000	4.6%	7.2%	5.1%

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes			
	11	13	16	17
History				
1973	4,744	4,374	3,281	3,424
($ per lb.)	.034	.135	.062	.118
Forecast				
1985	6,215	6,845	9,687	7,584
1986	6,451	7,132	10,423	8,168
1987	6,696	7,432	11,215	8,797
1988	6,951	7,744	12,068	9,474
1989	7,215	8,069	12,985	10,204
1990	7,489	8,408	13,972	10,989
1991	7,774	8,761	15,034	11,836
1992	8,069	9,129	16,176	12,747
1993	8,376	9,512	17,405	13,728
1994	8,694	9,912	18,728	14,786
1995	9,024	10,328	20,152	15,924
1996	9,367	10,762	21,683	17,150
1997	9,723	11,214	23,331	18,471
1998	10,093	11,685	25,104	19,893
1999	10,476	12,176	27,012	21,425
2000	10,874	12,687	29,065	23,075
Growth Rate Forecast, 1973-2000	3.8%	4.2%	7.6%	7.7%

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes			
	18	19	20	21
History				
1973	3,343	11,278	3,481	7,779
($ per lb.)	.254	.057	.094	.093
Forecast				
1985	7,161	20,290	9,172	11,763
1986	7,669	21,710	9,942	12,433
1987	8,214	23,230	10,778	13,142
1988	8,797	24,856	11,683	13,891
1989	9,422	26,596	12,664	14,683
1990	10,091	28,458	13,728	15,520
1991	10,807	30,450	14,881	16,405
1992	11,574	32,581	16,131	17,340
1993	12,396	34,862	17,486	18,328
1994	13,276	37,302	18,955	19,373
1995	14,219	39,913	20,547	20,477
1996	15,228	42,707	22,273	21,644
1997	16,310	45,697	24,144	22,878
1998	17,468	48,896	26,172	24,182
1999	18,708	52,318	28,371	25,560
2000	20,036	55,981	30,754	27,017
Growth Rate Forecast, 1973-2000	7.1%	7.0%	8.4%	5.7%

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes			
	22	31	36	42
History				
1973	6,213	2,914	19	2,304
($ per lb.)	.064	.053	I.V.D.*	.055
Forecast				
1985	14,025	6,200	26	7,333
1986	14,895	6,560	27	7,956
1987	15,818	6,940	28	8,633
1988	16,799	7,343	29	9,366
1989	17,840	7,768	29	10,162
1990	18,946	8,219	30	11,026
1991	20,121	8,696	31	11,963
1992	21,368	9,200	32	12,980
1993	22,693	9,734	33	14,084
1994	24,100	10,298	34	15,281
1995	25,595	10,895	36	16,580
1996	27,181	11,527	37	17,989
1997	28,867	12,196	38	19,518
1998	30,656	12,903	39	21,177
1999	32,557	13,652	40	22,977
2000	34,576	14,444	42	24,930
Growth Rate Forecast, 1973-2000	6.2%	5.8%	3.2%	8.5%

* Insufficient Value Data

Forecasts of Trade on U.S. Trade Routes Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes 55
History	
1973	99
($ per lb.)	I.V.D.*
Forecast	
1985	179
1986	191
1987	204
1988	217
1989	232
1990	248
1991	264
1992	282
1993	301
1994	321
1995	342
1996	365
1997	390
1998	416
1999	444
2000	473
Growth Rate Forecast, 1973-2000	6.7%

* Insufficient Value Data

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. Pacific Trade Routes			
	23	24	25	26
History				
1973	2,610	614	2,626	2,835
($ per lb.)	.085	.089	.078	.011
Forecast				
1985	8,402	1,631	4,713	4,343
1986	9,125	1,778	4,897	4,512
1987	9,909	1,938	5,088	4,688
1988	10,761	2,112	5,286	4,871
1989	11,687	2,302	5,492	5,061
1990	12,692	2,509	5,707	5,259
1991	13,784	2,735	5,929	5,464
1992	14,969	2,981	6,160	5,677
1993	16,256	3,250	6,401	5,898
1994	17,654	3,542	6,650	6,128
1995	19,173	3,861	6,910	6,367
1996	20,821	4,209	7,179	6,615
1997	22,612	4,587	7,459	6,873
1998	24,557	5,000	7,750	7,141
1999	26,669	5,450	8,052	7,420
2000	28,962	5,941	8,366	7,709
Growth Rate Forecast, 1973-2000	8.6%	9.0%	3.9%	3.9%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. Pacific Trade Routes 27	28	29	37
History				
1973	1,510	1,246	10,909	Negligible
($ per lb.)	.159	.111	.243	
Forecast				
1985	3,690	1,982	25,005	
1986	3,926	2,071	26,680	
1987	4,177	2,164	28,468	
1988	4,445	2,262	30,375	
1989	4,729	2,364	32,410	
1990	5,032	2,470	34,582	
1991	5,354	2,581	36,899	
1992	5,697	2,697	39,371	
1993	6,061	2,819	42,009	
1994	6,449	2,945	44,824	
1995	6,862	3,078	47,827	
1996	7,301	3,216	51,031	
1997	7,768	3,361	54,450	
1998	8,265	3,512	58,098	
1999	8,794	3,671	61,991	
2000	9,357	3,836	66,144	
Growth Rate Forecast, 1973-2000	6.4%	4.5%	6.7%	

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	Great Lakes Trade Routes 32	33	34	54
History 1973 ($ per lb.)	5,061 I.V.D.*	84 I.V.D.	326 I.V.D.	86 I.V.D.
Forecast				
1985	9,064	187	514	180
1986	9,345	201	540	190
1987	9,635	215	567	200
1988	9,933	231	595	211
1989	10,241	248	625	222
1990	10,559	266	656	234
1991	10,886	285	689	247
1992	11,224	306	723	260
1993	11,571	329	759	274
1994	11,930	353	797	289
1995	12,300	378	837	305
1996	12,681	406	879	321
1997	13,074	436	923	338
1998	13,480	467	969	357
1999	13,898	501	1,018	376
2000	14,328	538	1,069	396
Growth Rate Forecast, 1973-2000	3.1%	7.3%	5.0%	5.4%

* Insufficient Value Data

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	U.S. Pacific Trade Routes			
	38	43	53	65
History				
1973	Negligible	83	120	1,012
($ per lb.)		I.V.D.*	I.V.D.	I.V.D.
Forecast				
1985		,132	,209	1,458
1986		,138	,220	1,575
1987		,145	,231	1,701
1988		,152	,243	1,837
1989		,159	,255	1,984
1990		,167	,268	2,142
1991		,175	,282	2,314
1992		,183	,296	2,499
1993		,192	,311	2,699
1994		,201	,327	2,914
1995		,211	,344	3,148
1996		,221	,361	3,399
1997		,232	,380	3,671
1998		,243	,399	3,965
1999		,254	,419	4,282
2000		,267	,441	4,625
Growth Rate Forecast, 1973-2000		4.8%	5.1%	8.0%

* Insufficient Value Data

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Imports - in mil. lbs)

Year	Great Lakes Trade Routes			
	55	56	57	58
History				
1973	99	141	Insufficient	873
($ per lb.)	I.V.D.*	I.V.D.	Observation**	.033
Forecast				
1985	179	441		1,146
1986	191	474		1,188
1987	204	510		1,232
1988	217	548		1,278
1989	232	589		1,325
1990	248	633		1,374
1991	264	681		1,425
1992	282	732		1,478
1993	301	301		1,532
1994	321	786		1,589
1995	342	910		1,648
1996	365	977		1,709
1997	390	1,050		1,772
1998	416	1,129		1,838
1999	444	1,214		1,906
2000	473	1,305		1,976
Growth Rate Forecast 1973-2000	6.7%	7.5%		3.7%

* Insufficient Value Data

** Insufficient Observation

APPENDIX B

Aggregate Forecasts

of

Exports on U.S. Trade Routes, Dry Cargo

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. Atlantic Trade Routes			
	01	02	04	12
History				
1973	3,513	2,078	4,583	9,172
($ per lb.)	.998	.111	.113	.118
Forecast				
1985	12,831	4,013	11,875	28,846
1986	13,832	4,258	12,849	31,240
1987	14,911	4,517	13,902	33,833
1988	16,074	4,793	15,042	36,641
1989	17,327	5,085	16,276	39,682
1990	18,679	5,396	17,610	42,976
1991	20,136	5,725	19,054	46,543
1992	21,707	6,074	20,616	50,406
1993	23,400	6,444	22,307	54,590
1994	25,225	6,838	24,136	59,121
1995	27,192	7,255	26,115	64,028
1996	29,313	7,697	28,257	69,342
1997	31,600	8,167	30,574	75,098
1998	34,065	8,665	33,081	81,331
1999	36,722	9,194	35,793	88,021
2000	39,586	9,754	38,729	95,392
Growth Rate Forecast, 1973-2000	7.8%	6.1%	8.2%	8.3%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

	U.S. North Atlantic Trade Routes			
Year	05	06	07	08
History				
1973	3,299	3,825	2,569	5,308
($ per lb.)	.176	.011	.086	.228
Forecast				
1985	6,196	4,768	6,477	12,821
1986	6,512	4,992	6,937	13,500
1987	6,844	5,227	7,429	14,216
1988	7,193	5,472	7,957	14,969
1989	7,560	5,730	8,522	15,763
1990	7,946	5,999	9,127	16,598
1991	8,351	6,281	9,775	17,478
1992	8,777	6,576	10,469	18,404
1993	9,224	6,886	11,212	19,380
1994	9,695	7,209	12,008	20,407
1995	10,189	7,548	12,861	21,488
1996	10,709	7,903	13,774	22,627
1997	11,255	8,274	14,752	23,827
1998	11,829	8,663	15,799	25,089
1999	12,432	9,070	16,921	26,419
2000	13,066	9,497	18,122	27,819
Growth Rate Forecast, 1973-2000	5.1%	4.7%	7.1%	5.3%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. Atlantic Trade Routes	
	35	41
History		
1973	65	799
($ per lb.)	02	.150
Forecast		
1985	104	1,441
1986	108	1,548
1987	113	1,662
1988	118	1,785
1989	123	1,917
1990	128	2,059
1991	134	2,211
1992	140	2,375
1993	146	2,551
1994	152	2,740
1995	158	2,942
1996	165	3,160
1997	172	3,394
1998	180	3,645
1999	187	3,915
2000	196	4,205
Growth Rate Forecast, 1973-2000	4.3%	7.4%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

	U.S. North Atlantic Trade Routes	
Year	09	10
History		
1973	3,636	10,642
($ per lb.)	.038	.126
Forecast		
1985	9,610	22,789
1986	10,254	24,247
1987	10,941	25,799
1988	11,674	27,450
1989	12,456	29,207
1990	13,291	31,077
1991	14,181	33,065
1992	15,131	35,182
1993	16,145	37,433
1994	17,227	39,829
1995	18,381	42,378
1996	19,612	45,090
1997	20,926	47,976
1998	22,329	51,046
1999	23,825	54,313
2000	25,421	57,790
Growth Rate Forecast, 1973-2000	6.7%	6.4%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities (Exports - mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes			
	11	13	16	17
History				
1973	4,033	18,740	2,601	4,460
($ per lb.)	.143	.114	.095	.236
Forecast				
1985	6,343	34,115	6,202	9,261
1986	6,597	35,684	6,711	9,909
1987	6,861	37,326	7,261	10,603
1988	7,135	39,043	7,856	11,345
1989	7,420	40,839	8,500	12,139
1990	7,717	42,717	9,197	12,989
1991	8,026	44,682	9,952	13,898
1992	8,347	46,738	10,768	14,871
1993	8,681	48,888	11,651	15,912
1994	9,028	51,136	12,606	17,026
1995	9,389	53,489	13,640	18,218
1996	9,765	55,949	14,758	19,493
1997	10,155	58,523	15,968	20,857
1998	10,562	61,215	17,278	22,318
1999	10,984	64,031	18,694	23,880
2000	11,423	66,976	20,227	25,551
Growth Rate Forecast, 1973-2000	4.0%	4.6%	8.2%	7.0%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities (Exports - in mil. lbs)

	U.S. South Atlantic and Gulf Trade Routes			
Year	18	19	20	21
History				
1973	9,057	13,296	6,208	24,840
(¢ per lb.)	.271	.044	.079	.073
Forecast				
1985	19,300	32,938	15,877	49,435
1986	20,439	35,531	17,147	51,857
1987	21,645	38,444	18,519	54,398
1988	22,922	41,597	20,000	57,064
1989	24,274	45,008	21,600	59,860
1990	25,706	48,698	23,328	62,793
1991	27,223	52,691	25,195	65,870
1992	28,829	57,012	27,210	69,098
1993	30,530	61,687	29,387	72,483
1994	32,331	66,745	31,738	76,035
1995	34,239	72,219	34,277	79,761
1996	36,259	78,141	37,019	83,669
1997	38,398	84,548	39,981	87,769
1998	40,663	91,481	43,179	92,069
1999	43,063	98,982	46,634	96,581
2000	45,603	107,099	50,364	101,313
Growth Rate Forecast, 1973-2000	5.9%	8.2%	8.0%	4.9%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes			
	22	23	31	36
History				
1973	15,364	310	2,494	164
($ per lb.)	.148	.203	.200	I.V.D.*
Forecast				
1985	25,942	,957	5,570	288
1986	27,862	1,048	5,926	300
1987	29,923	1,147	6,306	312
1988	32,138	1,256	6,709	325
1989	34,516	1,375	7,139	338
1990	37,070	1,506	7,596	352
1991	39,813	1,649	8,082	366
1992	42,759	1,806	8,599	381
1993	45,924	1,977	9,149	397
1994	49,322	2,165	9,735	413
1995	52,972	2,371	10,358	430
1996	56,892	2,596	11,021	448
1997	61,102	2,842	11,726	466
1998	65,623	3,113	12,477	486
1999	70,480	3,408	13,275	505
2000	75,695	3,732	14,125	526
Growth Rate Forecast, 1973-2000	7.4%	9.5%	6.4%	4.1%

* Insufficient Value Data

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes
	42
History	
1973	757
($ per lb.)	.419
Forecast	
1985	1,729
1986	1,860
1987	2,002
1988	2,154
1989	2,318
1990	2,494
1991	2,683
1992	2,887
1993	3,107
1994	3,343
1995	3,597
1996	3,870
1997	4,164
1998	4,481
1999	4,821
2000	5,188
Growth Rate Forecast, 1973-2000	7.6%

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. Pacific Trade Routes			
	27	28	29	37
History				
1973	1,928	4,440	17,150	Negligible
($ per lb.)	.124	.115	.255	
Forecast				
1985	4,780	6,871	58,678	
1986	5,186	7,208	63,900	
1987	5,627	7,561	69,587	
1988	6,105	7,931	75,781	
1989	6,624	8,320	82,525	
1990	7,187	8,728	89,870	
1991	7,798	9,155	97,868	
1992	8,461	9,604	106,579	
1993	9,180	10,074	116,064	
1994	9,961	10,568	126,394	
1995	10,807	11,086	137,643	
1996	11,726	11,629	149,893	
1997	12,723	12,199	163,234	
1998	13,804	12,797	177,761	
1999	14,978	13,424	193,582	
2000	16,251	14,082	210,811	
Growth Rate Forecast, 1973-2000	8.5%	4.9%	8.9%	

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. Pacific Trade Routes
	38
History 1973 ($ per lb.)	negligible
Forecast	
1985	
1986	
1987	
1988	
1989	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	
1998	
1999	
2000	
Growth Rate Forecast, 1973-2000	

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	Great Lakes Trade Routes 32	33	34
History			
1973	8,533	423	3,206
($ per lb.)	.025	I.V.D.*	I.V.D.
Forecast			
1985	14,572	1,310	6,274
1986	15,140	1,442	6,701
1987	15,731	1,588	7,156
1988	16,344	1,748	7,643
1989	16,982	1,925	8,163
1990	17,644	2,119	8,718
1991	18,332	2,333	9,310
1992	19,047	2,569	9,944
1993	19,790	2,829	10,620
1994	20,562	3,114	11,342
1995	21,364	3,429	12,113
1996	22,197	3,775	12,937
1997	23,062	4,156	13,816
1998	23,962	4,576	14,756
1999	24,896	5,038	15,759
2000	25,867	5,547	16,831
Growth Rate Forecast, 1973-2000	3.9%	10.1%	6.8%

* Insufficient Value Data

Forecasts of Trade on U.S. Trade Routes, Excluding Liquid Bulk Commodities
(Exports - in mil. lbs)

Year	U.S. South Atlantic and Gulf Trade Routes			
	22	23	31	36
History				
1973	15,364	310	2,494	36
($ per lb.)	.148	.203	.200	I.V.D.*
Forecast				
1985	25,942	957	5,570	288
1986	27,862	1,048	5,926	300
1987	29,923	1,147	6,306	312
1988	32,138	1,256	6,709	325
1989	34,516	1,375	7,139	338
1990	37,070	1,506	7,596	352
1991	39,813	1,649	8,082	366
1992	42,759	1,806	8,599	381
1993	45,924	1,977	9,149	397
1994	49,322	2,165	9,735	413
1995	52,972	2,371	10,358	430
1996	56,892	2,596	11,021	448
1997	61,102	2,842	11,726	466
1998	65,623	3,113	12,477	486
1999	70,480	3,408	13,275	505
2000	75,695	3,732	14,125	526
Growth Rate Forecast, 1973-2000	7.4%	9.5%	6.4%	4.1%

* Insufficient Value Data

APPENDIX C

Forecasts of Import Shares on U.S. Trade Routes, Dry Cargo

Detailed Forecast by
Trade Route, Imports

		01		02	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	6.0%	8.3%	10.4%	17.1%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	63.4	44.1	67.9	48.3
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	30.6	47.6	21.7	34.6
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		04		05	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	1.0%	0.0%	37.9%	46.3%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	95.8	100.0	32.1	20.3
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	3.2	0.0	30.0	33.4
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

	06		07	
	1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
Container Share of Total*	25.1%	25.7%	65.9%	65.1%
1 Container, Reefer				
2 Container				
3 Container				
4 Container				
5 Container				
6 Container				
Dry Bulk Share of Total*	22.5	21.7	1.3	1.4
10 Dry Bulk				
11 Dry Bulk				
12 Dry Bulk, Perishable				
14 Dry Bulk				
16 Dry Bulk, Perishable				
Break Bulk Share of Total**	52.4	52.6	32.8	33.5
20 Break Bulk (live animals)				
21 Break Bulk				
22 Break Bulk				
23 Break Bulk				
24 Break Bulk				
25 Break Bulk				
26 Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		08		09	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	15.7%	22.0%	27.2%	23.9%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	41.9	24.6	35.9	33.4
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	42.4	53.4	36.9	42.7
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by Trade Route, Imports

	10		11	
	1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
Container Share of Total*	10.7%	0.0%	15.6%	14.5%
1 Container, Reefer				
2 Container				
3 Container				
4 Container				
5 Container				
6 Container				
Dry Bulk Share of Total*	78.3	85.9	15.9	15.4
10 Dry Bulk				
11 Dry Bulk				
12 Dry Bulk, Perishable				
14 Dry Bulk				
16 Dry Bulk, Perishable				
Break Bulk Share of Total**	11.0	14.1	68.3	70.1
20 Break Bulk (live animals)				
21 Break Bulk				
22 Break Bulk				
[illegible]3 Break Bulk				
24 Break Bulk				
25 Break Bulk				
26 Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		12		13	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	34.3%	0.0%	9.3%	8.2%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	2.9	0.0	63.0	65.8
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	62.8	100.0	27.7	26.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

	16		17	
	1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
Container Share of Total*	16.3%	12.0%	6.9%	7.2%
1 Container, Reefer				
2 Container				
3 Container				
4 Container				
5 Container				
6 Container				
Dry Bulk Share of Total*	57.7	64.9	9.9	
10 Dry Bulk				
11 Dry Bulk				
12 Dry Bulk, Perishable				
14 Dry Bulk				
16 Dry Bulk, Perishable				
Break Bulk Share of Total**	26.0	23.1	83.2	88.9
20 Break Bulk (live animals)				
21 Break Bulk				
22 Break Bulk				
23 Break Bulk				
24 Break Bulk				
25 Break Bulk				
26 Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		18		19	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	35.3%	42.9%	2.6%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	43.4	34.2	89.3	100.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	21.3	22.9	8.1	0.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

	20		21	
	1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
Container Share of Total*	5.6%	6.3%	13.0%	10.0%
1 Container, Reefer				
2 Container				
3 Container				
4 Container				
5 Container				
6 Container				
Dry Bulk Share of Total*	43.4	31.5	5.8	0.0
10 Dry Bulk				
11 Dry Bulk				
12 Dry Bulk, Perishable				
14 Dry Bulk				
16 Dry Bulk, Perishable				
Break Bulk Share of Total**	51.0	62.2	81.2	90.0
20 Break Bulk (live animals)				
21 Break Bulk				
22 Break Bulk				
23 Break Bulk				
24 Break Bulk				
25 Break Bulk				
26 Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		22		23	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	13.1%	4.4%	0.2%	0.5%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	2.1	1.5	77.9	63.4
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	84.8	94.1	21.9	36.1
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		24		25	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	9.3%	14.9%	15.7%	10.9%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	71.7	55.7	67.3	72.9
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	19.0	29.4	17.0	16.2
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		26		27	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	43.9%	38.9%	7.4%	17.3%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	2.8	1.8	9.2	14.5
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	53.3	59.3	83.4	68.2
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		28		29	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	11.5%	12.6%	31.8%	32.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	84.7	83.0	6.8	0.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	3.8	4.4	61.4	68.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Imports

		31		32	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	5.2%	0.0%	5.2%	7.3%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	55.8	61.4	55.8	
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	39.0	38.6	39.0	91.5
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

APPENDIX D

Forecasts of Export Shares on U.S. Trade Routes, Dry Cargo

Detailed Forecast by
Trade Route, Exports

		01		02	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	2.1%	0.0%	10.9%	100.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	75.6	100.0	44.5	0.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	22.3	0.0	44.6	0.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		04		05	
		1973 Share	1985-2000 Share**	1973 Share	1985-200 Share**
	Container Share of Total*	48.4%	29.6%	6.8%	15.3%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	31.6	70.4	79.0	53.1
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	48.4	0.0	14.2	31.6
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		06		07	
		1973 Share	1985-2000 Share**	1973 Share	1985-200. Share**
	Container Share of Total*	8.6%	12.0%	4.1%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	74.3	69.1	87.3	100.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	17.1	18.9	8.6	0.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		08		09	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	6.5%	0.0%	1.6%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	76.2	100.0	90.2	100.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	17.2	0.0	8.2	0.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		10		11	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	4.9%	4.0%	6.0%	6.5%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	74.6	79.0	39.4	37.4
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	20.5	17.0	54.6	56.1
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		12		13	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	1.3%	8.6%	0.8%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	94.5	71.5	75.9	69.9
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	4.2	19.9	23.3	30.1
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		16		17	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	7.9%	0.0%	5.8%	100.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	15.1	0.0	11.2	0.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	77.0	100.0	83.0	0.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		18		19	
		1973 Share	1985-2000 Share**	1973 Share	1985-200[illegible] Share**
	Container Share of Total*	5.4%	5.1%	2.7%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	54.1	43.9	48.7	0.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	40.5	51.0	48.6	100.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		20		21	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	1.9%	1.8%	1.7%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	52.2	45.1	66.8	100.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	45.9	53.1	31.5	0.0
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		24		25	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	17.6%	23.4%	8.2%	7.4%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	5.4	2.4	62.8	65.0
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	77.0	74.2	29.0	27.6
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		22		23	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	0.5%	0.0%	30.1%	31.8%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	88.3	100.0	12.4	8.4
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	11.2	0.0	57.5	59.8
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		26		27	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	25.0%	0.0%	7.8%	7.2%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	40.9	100.0	10.1	9.2
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	34.1	0.0	82.1	83.6
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

		28		29	
		1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
	Container Share of Total*	7.9%	100.0%	2.8%	0.0%
1	Container, Reefer				
2	Container				
3	Container				
4	Container				
5	Container				
6	Container				
	Dry Bulk Share of Total*	57.4	0.0	32.7	40.4
10	Dry Bulk				
11	Dry Bulk				
12	Dry Bulk, Perishable				
14	Dry Bulk				
16	Dry Bulk, Perishable				
	Break Bulk Share of Total**	34.7	0.0	64.5	59.6
20	Break Bulk (live animals)				
21	Break Bulk				
22	Break Bulk				
23	Break Bulk				
24	Break Bulk				
25	Break Bulk				
26	Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

Detailed Forecast by
Trade Route, Exports

	31		32	
	1973 Share	1985-2000 Share**	1973 Share	1985-2000 Share**
Container Share of Total*	3.0%	3.5%	5.7%	5.4%
1 Container, Reefer				
2 Container				
3 Container				
4 Container				
5 Container				
6 Container				
Dry Bulk Share of Total*	54.1	58.8	73.7	78.2
10 Dry Bulk				
11 Dry Bulk				
12 Dry Bulk, Perishable				
14 Dry Bulk				
16 Dry Bulk, Perishable				
Break Bulk Share of Total**	42.9	37.7	20.6	16.4
20 Break Bulk (live animals)				
21 Break Bulk				
22 Break Bulk				
23 Break Bulk				
24 Break Bulk				
25 Break Bulk				
26 Break Bulk				

* Total-excluding Liquid Bulk

** Forecast Share

APPENDIX E

List of Trade Routes of the U.S.

Trade Routes of the U.S.*	
Trade Route Number	1973 Description
0100	U. S. Atlantic/East Coast South America
0101	U. S. Atlantic/Brazil
0102	U. S. Atlantic/Uruguay
0103	U. S. Atlantic/Argentina
0200	U. S. Atlantic/West Coast South America
0201	U. S. Atlantic/Colombia (West Coast)
0202	U. S. Atlantic Ecuador
0203	U. S. Atlantic/Peru
0204	U. S. Atlantic/Chile
0400	U. S. Atlantic/Caribbean (Incl. Cristobal), East Coast Mexico
0401	U. S. Atlantic/Mexico (East Coast)
0402	U. S. Atlantic/Colombia (Carib.)
0403	U. S. Atlantic/Venezuela
0404	U. S. Atlantic/Netherlands Antilles
0500	U. S. North Atlantic/United Kingdom, Ireland (Eire)
0600	U. S. North Atlantic/Scandinavia and Baltic (Incl. Nlfd., Greenland & Iceland)
0700	U. S. North Atlantic/West Germany (North Sea)
0800	U. S. North Atlantic/Netherlands, Belgium
0801	U. S. North Atlantic/Netherlands
0802	U. S. North Atlantic/Belgium
0900	U. S. North Atlantic/France (Atlantic), Spain (N. of Portugal)
0901	U. S. North Atlantic/France (Atlantic)
0902	U. S. North Atlantic/Spain (N. of Portugal)
1000	U. S. North Atlantic/Mediterranean, Black Sea, Portugal, Spain (South of Portugal), Morocco, and Azores
1001	U. S. North Atlantic/France (Med.)
1002	U. S. North Atlantic/Spain (S.E. of Portugal & Med.)
1003	U. S. North Atlantic/Portugal
1004	U. S. North Atlantic/Italy
1005	U. S. North Atlantic/Yugoslavia
1006	U. S. North Atlantic/Greece
1007	U. S. North Atlantic/Turkey
1008	U. S. North Atlantic/Syria
1009	U. S. North Atlantic/Lebanon
1010	U. S. North Atlantic/Israel (Med.)1011
1011	U. S. North Atlantic/Egypt (Med.)
1012	U. S. North Atlantic/Libya, Tunisia, Algeria, Morocco

*Maritime Administration Office of Market Development

Trade Routes of the U.S*

Trade Route Number	1973 Description
1100	U. S. South Atlantic/United Kingdom and Ireland (Eire), Continental Europe North of Portugal
1101	U. S. South Atlantic/United Kingdom, Ireland (Eire)
1102	U. S. South Atlantic/Spain (N. of Portugal)
1103	U. S. South Atlantic/France (Atlantic)
1104	U. S. South Atlantic/Belgium
1105	U. S. South Atlantic/Netherlands
1106	U. S. South Atlantic/West Germany (North Sea)
1107	U. S. South Atlantic/Scandinavia and Baltic
1200	U. S. Atlantic/Far East
1201	U. S. Atlantic/Japan
1202	U. S. Atlantic/Republic of Korea
1203	U. S. Atlantic/Okinawa
1204	U. S. Atlantic/Taiwan
1205	U. S. Atlantic/Hong Kong
1206	U. S. Atlantic/Philippines
1207	U. S. Atlantic/South Vietnam
1208	U. S. Atlantic/Thailand
1300	U. S. South Atlantic and Gulf/Mediterranean, Black Sea, Portugal, Spain (South of Portugal), Morocco, and Azores
1301	U. S. South Atlantic and Gulf/France (Med.)
1302	U. S. South Atlantic and Gulf/Spain (S.E. of Portugal and (Med.)
1303	U. S. South Atlantic and Gulf/Portugal
1304	U. S. South Atlantic and Gulf/Italy
1305	U. S. South Atlantic and Gulf/Yugoslavia
1306	U. S. South Atlantic and Gulf/Greece
1307	U. S. South Atlantic and Gulf/Turkey
1308	U. S. South Atlantic and Gulf/Syria
1309	U. S. South Atlantic and Gulf/Lebanon
1310	U. S. South Atlantic and Gulf/Israel (Med.)
1311	U. S. South Atlantic and Gulf/Egypt (Med.)
1312	U. S. South Atlantic and Gulf/Libya, Tunisia, Algeria, Morocco
4100 (14-1.00)	U. S. Atlantic (Service 1)/West Africa, Canary Is., Cape Verde Is., and Madeira Is.
4101 (14-1.01)	U. S. Atlantic/Senegal through Ivory Coast
4102 (14-1.02)	U. S. Atlantic/Ghana through Cameroon
4103 (14-1.03)	U. S. Atlantic/Equatorial Guinea through Angola

*Maritime Administration Office of Market Development

Trade Route Number	1973 Description
4200 (14-2.00)	U. S. Gulf (Service 2)/West Africa, Canary Is., Cape Verde Is., and Madeira Is.
4201 (14-2.01)	U. S. Gulf/Senegal through Ivory Coast
4202 (14-2.02)	U. S. Gulf/Ghana through Cameroon
4203 (14-2.03)	U. S. Gulf/Equatorial Guinea through Angola
4300 (14-3.00)	U. S. Pacific/West Coast Africa, Canary Is., Cape Verde Is., and Madeira Is.
5100 (15-A.00)	U. S. Atlantic/South & East Africa, Malagasy Rep., St. Helena, Ascension Is.
5101 (15-A.01	U. S. Atlantic/Rep. of S. Africa
5102 (15-A.02	U. S. Atlantic/Mozambique
5103 (15-A.03	U. S. Atlantic/Tanzania, Kenya
5104 (15-A.04)	U. S. Atlantic/Malagasy Rep.
5200 (15-B.00)	U. S. Gulf/South & East Africa, Malagasy Rep., St. Helena, Ascension Is.
5201 (15-B.01)	U. S. Gulf/Rep. of S. Africa
5202 (15-B.02)	U. S. Gulf/Mozambique
5203 (15-B.03)	U. S. Gulf/Tanzania, Kenya
5204 (15-B.04)	U. S. Gulf/Malagasy Rep.
5300 (15-C.00)	U. S. Pacific/South & East Africa, Malagasy Republic, St. Helena, Ascension Is.
1600	U. S. Atlantic, Gulf/Australia
1601	U. S. Atlantic, Gulf/Australia
1602	U. S. Atlantic, Gulf/New Zealand
1700	U. S. Atlantic, Gulf, and Pacific/Indonesia, Malaysia, Singapore
1701	U. S. Atlantic/Indonesia
1702	U. S. Gulf/Indonesia
1703	U. S. Pacific/Indonesia
1704	U. S. Atlantic/Malaysia
1705	U. S. Gulf/Malaysia
1706	U. S. Pacific/Malaysia
1707	U. S. Atlantic/Singapore
1708	U. S. Gulf/Singapore
1709	U. S. Pacific/Singapore
1800	U. S. Atlantic, Gulf/India, Pakistan, Ceylon, Burma, Persian Gulf, Gulf of Aden, Red Sea
1801	U. S. Atlantic, Gulf/India
1802	U. S. Atlantic, Gulf/Pakistan

Trade Routes of the U.S.*

*Maritime Administration Office of Market Development

Trade Routes of the U.S.*

Trade Route Number	1973 Description
1803	U. S. Atlantic, Gulf/Ceylon
1900	U. S. Gulf/Caribbean (Incl. Cristobal), East Coast Mexico
1901	U. S. Gulf/Mexico (East Coast)
1902	U. S. Gulf/Colombia (Carib.)
1903	U. S. Gulf/Venezuela
1904	U. S. Gulf/Netherlands Antilles
2000	U. S. Gulf/East Coast South America
2001	U. S. Gulf/Brazil
2002	U. S. Gulf/Uruguary
2003	U. S. Gulf/Argentina
2100	U. S. Gulf/United Kingdom and Ireland (Eire), Continental Europe North of Portugal
2101	U. S. Gulf/United Kingdom, Ireland (Eire)
2102	U. S. Gulf/Spain (N. of Portugal)
2103	U. S. Gulf/France (Atlantic)
2104	U. S. Gulf/Belgium
2105	U. S. Gulf/Netherlands
2106	U. S. Gulf/West Germany (North Sea)
2107	U. S. Gulf/Scandinavia and Baltic
2200	U. S. Gulf/Far East
2201	U. S. Gulf/Japan
2202	U. S. Gulf/Rep.of Korea
2203	U. S. Gulf/Okinawa
2204	U. S. Gulf/Taiwan
2205	U. S. Gulf/Hong Kong
2206	U. S. Gulf/Philippines
2207	U. S. Gulf/South Vietnam
2208	U. S. Gulf/Thailand
2300	U. S. Pacific/Caribbean (Incl. Cristobal), East Coast Mexico
2301	U. S. Pacific/Colombia (Carib.)
2302	U. S. Pacific/Venezuela
2400	U. S. Pacific/East Coast South America
2401	U. S. Pacific/Brazil
2402	U. S. Pacific/Uruguay
2403	U. S. Pacific/Argnetina
2500	U. S. Pacific/West Coast South America, Central America and Mexico, Canal Zone (W.C.)

*Maritime Administration Office of Market Development

Trade Routes of the U.S.*

Trade Route Number	1973 Description
2900	U. S. Pacific, Hawaii, Alaska/Far East
2901	U. S. Pacific, Hawaii, Alaska/Japan
2902	U. S. Pacific, Hawaii, Alaska/Rep. of Korea
2903	U. S. Pacific, Hawaii, Alaska/Okinawa
2904	U. S. Pacific, Hawaii, Alaska/Taiwan
2905	U. S. Pacific, Hawaii, Alaska/Hong Kong
2906	U. S. Pacific, Hawaii, Alaska/Philippines
2907	U. S. Pacific, Hawaii, Alaska/South Vietnam
2908	U. S. Pacific, Hawaii, Alaska/Thailand
3100	U. S. Gulf/West Coast South America
3101	U. S. Gulf/Colombia (West Coast)
3102	U. S. Gulf/Ecuador
3103	U. S. Gulf/Peru
3104	U. S. Gulf/Chile
3200	U. S. Great Lakes/United Kingdom & Ireland (Eire), Continental Europe North of Portugal
3201	U. S. Great Lakes/United Kingdom and Ireland (Eire)
3202	U. S. Great Lakes/Spain (N. of Portugal)
3203	U. S. Great Lakes/France (Atlantic)
3204	U. S. Great Lakes/Belgium
3205	U. S. Great Lakes/Netherlands
3206	U. S. Great Lakes/West Germany (North Sea)
3207	U. S. Great Lakes/Scandinavia and Baltic
3300	U. S. Great Lakes/Caribbean (Incl. Cristobal), East Coast Mexico
3400	U. S. Great Lakes/Mediterranean, Black Sea, Portugal, Spain (South of Portugal), Morocco
3500	U. S. Atlantic/Great Lakes Canada
3600	U. S. Gulf/Great Lakes Canada
3700	California/Great Lakes Canada
3800	Washington, Oregon/Great Lakes Canada
5400	U. S. Great Lakes/West Africa
5500	U. S. Great Lakes/South and East Africa
5600	U. S. Great Lakes/Red Sea, India Perisan Gulf, Indonesia, Malaya, Singapore
5700	Round-the-World
5800	U. S. Great Lakes/Pacific Canada

*Maritime Administration Office of Market Development

Trade Routes of the U.S.*	
Trade Route Number	1973 Description
2501	U. S. Pacific/Mexico, W. Coast Central America, Canal Zone (W.C.)
2502	U. S. Pacific/Colombia (West Coast)
2503	U. S. Pacific/Ecuador
2504	U. S. Pacific/Peru
2505	U. S. Pacific/Chile
2600	U. S. Pacific, Hawaii, Alaska/United Kingdom and Ireland (Eire), Continental Europe North of Portugal
2601	U. S. Pacific, Hawaii, Alaska/United Kingdom, Ireland (Eire)
2602	U. S. Pacific, Hawaii, Alaska/Spain (N. of Portugal)
2603	U. S. Pacific, Hawaii, Alaska/France (Atlantic)
2604	U. S. Pacific, Hawaii, Alaska/Belgium
2605	U. S. Pacific, Hawaii, Alaska/Netherlands
2606	U. S. Pacific, Hawaii, Alaska/West Germany North Sea)
2607	U. S. Pacific, Hawaii, Alaska/Scandinavia and Baltic
6500 (26-C.00)	U. S. Pacific,/Mediterranean, Black Sea, Portugal, Spain (South of Portugal), Morocco,,and Azores
6501 (26-C.01)	U. S. Pacific/France (Med.)
6502 (26-C.02)	U. S. Pacific/Spain (S.E. of Portugal & Med.)
6503 (26-C.03)	U. S. Pacific/Portugal
6504 (26-C.04)	U. S. Pacific/Italy
6505 (26-C.05)	U. S. Pacific/Yugoslavia
6506 (26-C.06)	U. S. Pacific/Greece
6507 (26-C.07)	U. S. Pacific/Turkey
6508 (26-C.08)	U. S. Pacific/Syria
6509 (26-C.09)	U. S. Pacific/Lebanon
6510 (26-C.10)	U. S. Pacific/Israel (Med.)
6511 (26-C.11)	U. S. Pacific/Egypt (Med.)
6512 (26-C.12)	U. S. Pacific/Hawaii Tunisia, Algeria, Morocco
2700	U. S. Pacific, Hawaii/Australia
2701	U. S. Pacific, Hawaii/Australia
2702	U. S. Pacific, Hawaii/New Zealand
2800	U. S. Pacific/India, Pakistan, Ceylon, Burma, Persian Gulf, Gulf of Aden, Red Sea
2801	U. S. Pacific/India
2802	U. S. Pacific/Pakistan
2803	U. S. Pacific/Ceylon

*Maritime Administration Office of Market Development

Trade Routes of the U.S.*

Trade Route Number	1973 Description
5900	U. S. Great Lakes/Far East
6000	U. S. Great Lakes/Australasia
7100	U. S. Atlantic/West Coast Central America and Mexico
7200	U. S. Gulf/West Coast Central America and Mexico
7700	U. S. Atlantic/Pacific Canal Zone
7800	U. S. Gulf/Pacific Canal Zone
8000	U. S. Great Lakes/West Coast South America, Central America and Mexico
8100	U. S. Atlantic/Atlantic Canada
8200	U. S. Gulf/Atlantic Canada
8300	U. S. Pacific/Atlantic Canada
8400	U. S. Great Lakes/East Coast South America
8500	U. S. Atlantic/Pacific Canada
8600	U. S. Gulf/Pacific Canad a
8700	U. S. Pacific Canada
8900	U. S. Great Lakes/Atlantic Canada
9100	U. S. Rico/Foreign - Virgin Islands/Foreign Hawaii/Foreign (Except T.R. - 2600, 2700,2900, and their subdivisions)
9300	Alaska/Foreign (Except T.R. - 2600, 2900, and their subdivisions)
6100	U. S. Great Lakes/Great Lakes Canada (TransLakes)

*Maritime Administration Office of Market Development

Essential Trade Routes:

0100 through 4200 (14-2.00)
5100 (15-A.00 & 5200 (15-B.00)
1600 through 2600
2700 through 3400

Note: Trade route subdivisions carry numbers ending in other than 00 (e.g., 0101 U. S. Atlantic/Brazil).

APPENDIX F

Casualty Costs-by Cause, by Vessel Type, by Location

USSA, Inc.

Damage Survey Analysis

for

ECON, Inc.

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
GROUNDINGS			
CANADA PACIFIC			
7. BULK CARRIERS	1	17,000	3
CASUALTY LOCATION TOTALS	1	17,000	3
US PACIFIC			
2. GENERAL CARGO SHIPS	10	487,200	85
3. TANK SHIPS	3	44,900	8
4. TANK SHIPS	3	173,700	17
7. BULK CARRIERS	10	744,200	81
8. BULK CARRIERS - ORE/OIL	2	565,000	37
12. CONTAINER/CARGO SHIPS	1	13,500	2
17. RAILROAD CAR FERRIES	1	23,700	10
19. BARGE CARRIERS	1	71,700	3
CASUALTY LOCATION TOTALS	31	2,123,900	243
PACIFIC CAL. TO PANAMA			
2. GENERAL CARGO SHIPS	6	251,400	39
4. TANK SHIPS	1	40,500	6
7. BULK CARRIERS	2	160,000	12
13. CONTAINER SHIPS (EXCLUSIVELY)	1	162,000	11
CASUALTY LOCATION TOTALS	10	613,900	68
PACIFIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	14	606,900	94
7. BULK CARRIERS	3	563,700	36
12. CONTAINER/CARGO SHIPS	1	40,000	5
13. CONTAINER SHIPS (EXCLUSIVELY)	1	24,000	4
CASUALTY LOCATION TOTALS	19	1,234,600	139
SOUTH TIP OF SOUTH AMERICA			
4. TANK SHIPS	1	6,643,200	

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
CASUALTY LOCATION TOTALS	1	6,643,200	
ATLANTIC SOUTH AMERICA			
1. GENERAL CARGO SHIPS	1	75,700	10
2. GENERAL CARGO SHIPS	11	471,900	96
3. TANK SHIPS	1	22,000	10
4. TANK SHIPS	9	535,500	72
7. BULK CARRIERS	18	1,042,900	173
8. BULK CARRIERS - ORE/OIL	5	180,600	23
9. BULK CARRIERS - SELF-UNLOADERS	2	57,000	16
CASUALTY LOCATION TOTALS	47	2,385,600	400
GULF AND CARRIBBEAN			
1. GENERAL CARGO SHIPS	3	3,333,200	56
2. GENERAL CARGO SHIPS	27	2,217,800	249
3. TANK SHIPS	6	385,300	29
4. TANK SHIPS	49	3,419,200	3[illegible]
6. TANK SHIPS	1	32,700	2
7. BULK CARRIERS	55	5,501,000	458
8. BULK CARRIERS - ORE/OIL	3	132,400	17
9. BULK CARRIERS - SELF-UNLOADERS	10	801,400	90
10. BULK CHEMICAL CARRIERS	6	397,600	50
12. CONTAINER/CARGO SHIPS	2	947,200	27
13. CONTAINER SHIPS (EXCLUSIVELY)	2	434,600	16
15. REFRIGERATED CARGO SHIPS	1	25,800	3
16. PASSENGER SHIPS	1	18,900	3
CASUALTY LOCATION TOTALS	166	17,647,100	1,321
SOUTH ATLANTIC US TIP			
2. GENERAL CARGO SHIPS	2	678,900	37
4. TANK SHIPS	2	778,900	15
7. BULK CARRIERS	2	90,300	15
16. PASSENGER SHIPS	1	28,100	6
CASUALTY LOCATION TOTALS	7	1,576,200	73

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
SOUTH ATLANTIC US			
2. GENERAL CARGO SHIPS	5	562,100	49
3. TANK SHIPS	4	96,200	35
4. TANK SHIPS	5	302,700	33
7. BULK CARRIERS	3	38,100	10
9. BULK CARRIERS - SELF-UNLOADERS	1	54,000	5
11. LIQUID GAS CARRIERS	1	29,300	6
13. CONTAINER SHIPS (EXCLUSIVELY)	1	50,000	2
CASUALTY LOCATION TOTALS	20	1,132,400	140
US NORTH ATLANTIC			
2. GENERAL CARGO SHIPS	8	279,500	49
3. TANK SHIPS	5	367,800	38
4. TANK SHIPS	25	2,375,700	317
7. BULK CARRIERS	14	726,900	92
8. BULK CARRIERS - ORE/OIL	3	80,400	12
9. BULK CARRIERS - SELF-UNLOADERS	1	88,000	16
10. BULK CHEMICAL CARRIERS	2	118,300	18
12. CONTAINER/CARGO SHIPS	4	786,100	63
13. CONTAINER SHIPS (EXCLUSIVELY)	7	1,446,600	138
15. REFRIGERATED CARGO SHIPS	1	57,600	3
16. PASSENGER SHIPS	1	3,800	1
CASUALTY LOCATION TOTALS	71	6,330,700	747
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	1	18,400	6
4. TANK SHIPS	1	36,100	5
9. BULK CARRIERS - SELF-UNLOADERS	1	86,500	6
CASUALTY LOCATION TOTALS	3	141,000	17
ST. LAWRENCE SEAWAY			
2. GENERAL CARGO SHIPS	4	513,500	50

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
4. TANK SHIPS	4	1,281,300	91
7. BULK CARRIERS	7	742,000	63
8. BULK CARRIERS - ORE/OIL	1	73,900	20
CASUALTY LOCATION TOTALS	16	2,610,700	224
GREAT LAKES			
2. GENERAL CARGO SHIPS	1	39,000	4
4. TANK SHIPS	3	139,400	19
7. BULK CARRIERS	16	762,400	72
9. BULK CARRIERS - SELF-UNLOADERS	10	704,800	91
16. PASSENGER SHIPS	1	23,000	4
CASUALTY LOCATION TOTALS	31	1,668,600	190
ENGLAND			
2. GENERAL CARGO SHIPS	1	35,900	7
4. TANK SHIPS	9	1,041,800	114
7. BULK CARRIERS	4	2,695,900	123
13. CONTAINER SHIPS (EXCLUSIVELY)	2	198,000	12
CASUALTY LOCATION TOTALS	16	3,971,600	256
NORTH SEA			
13. CONTAINER SHIPS (EXCLUSIVELY)	1	134,300	9
CASUALTY LOCATION TOTALS	1	134,300	9
BALTIC SEA			
2. GENERAL CARGO SHIPS	1	297,800	10
4. TANK SHIPS	5	447,500	84
7. BULK CARRIERS	10	745,800	108
CASUALTY LOCATION TOTALS	16	1,491,100	202
WEST COAST OF EUROPE			

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
2. GENERAL CARGO SHIPS	5	93,800	24
4. TANK SHIPS	9	541,400	79
7. BULK CARRIERS	10	5,240,300	47
12. CONTAINER/CARGO SHIPS	1	61,800	6
13. CONTAINER SHIPS (EXCLUSIVELY)	3	388,300	34
CASUALTY LOCATION TOTALS	28	6,325,600	190
EUROPE, MEDITER.			
2. GENERAL CARGO SHIPS	6	207,100	36
4. TANK SHIPS	11	9,839,300	180
7. BULK CARRIERS	9	738,000	93
8. BULK CARRIERS - ORE/OIL	4	398,000	37
19. BARGE CARRIERS	1	75,300	5
CASUALTY LOCATION TOTALS	31	11,257,700	351
AFRICA, MEDITER.			
3. TANK SHIPS	1	62,400	10
4. TANK SHIPS	1	115,200	9
CASUALTY LOCATION TOTALS	2	177,600	19
WEST AFRICA			
2. GENERAL CARGO SHIPS	2	95,500	15
4. TANK SHIPS	1	86,100	6
7. BULK CARRIERS	3	318,800	24
15. REFRIGERATED CARGO SHIPS	1	3,300	3
CASUALTY LOCATION TOTALS	7	503,700	48
TIP OF AFRICA			
4. TANK SHIPS	1	128,900	15
CASUALTY LOCATION TOTALS	1	128,900	15

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
EAST OF AFRICA			
2. GENERAL CARGO SHIPS	3	60,600	13
4. TANK SHIPS	4	356,200	44
7. BULK CARRIERS	2	85,900	6
8. BULK CARRIERS - ORE/OIL	2	80,400	9
CASUALTY LOCATION TOTALS	11	583,100	72
PERSIAN GULF			
2. GENERAL CARGO SHIPS	1	8,200	4
4. TANK SHIPS	22	2,887,200	217
6. TANK SHIPS	1	55,100	5
7. BULK CARRIERS	2	42,700	20
8. BULK CARRIERS - ORE/OIL	8	402,500	47
CASUALTY LOCATION TOTALS	34	3,395,700	293
SEA OF BENGAL			
1. GENERAL CARGO SHIPS	1	300	1
2. GENERAL CARGO SHIPS	6	346,800	35
4. TANK SHIPS	3	247,900	18
6. TANK SHIPS	1	1,757,600	35
7. BULK CARRIERS	2	37,100	6
CASUALTY LOCATION TOTALS	13	2,389,700	95
INDONESIA			
2. GENERAL CARGO SHIPS	16	5,620,000	112
4. TANK SHIPS	5	630,000	44
5. TANK SHIPS	1	25,600	3
7. BULK CARRIERS	3	145,400	14
13. CONTAINER SHIPS (EXCLUSIVELY)	1	149,300	7
15. REFRIGERATED CARGO SHIPS	1	11,000	1
19. BARGE CARRIERS	1	67,400	3
CASUALTY LOCATION TOTALS	28	6,648,700	184

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
AUST/NZ			
2. GENERAL CARGO SHIPS	1	11,500	2
4. TANK SHIPS	2	136,400	16
7. BULK CARRIERS	5	458,000	38
CASUALTY LOCATION TOTALS	8	605,900	56
NORTH PACIFIC			
1. GENERAL CARGO SHIPS	1	33,200	5
2. GENERAL CARGO SHIPS	15	725,900	90
3. TANK SHIPS	2	104,100	13
4. TANK SHIPS	4	1,020,900	78
7. BULK CARRIERS	14	2,574,000	203
8. BULK CARRIERS - ORE/OIL	2	91,200	22
12. CONTAINER/CARGO SHIPS	3	61,000	10
15. REFRIGERATED CARGO SHIPS	3	723,800	19
CASUALTY LOCATION TOTALS	44	5,334,100	440
2. GENERAL CARGO SHIPS	2	90,200	8
3. TANK SHIPS	1	54,200	6
4. TANK SHIPS	7	577,800	49
7. BULK CARRIERS	1	26,300	3
10. BULK CHEMICAL CARRIERS	1	21,400	10
CASUALTY LOCATION TOTALS	12	769,900	76
ALLEGED CAUSE TOTALS	675	87,842,500	5,871

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
COLLISION - OBJECT			
ALASKA			
16. PASSENGER SHIPS	1	120,500	7
CASUALTY LOCATION TOTALS	1	120,500	7
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	1	13,600	3
4. TANK SHIPS	1	22,800	5
7. BULK CARRIERS	2	40,000	5
9. BULK CARRIERS - SELF-UNLOADERS	1	47,300	3
12. CONTAINER/CARGO SHIPS	2	17,800	8
CASUALTY LOCATION TOTALS	7	141,500	24
US PACIFIC			
1. GENERAL CARGO SHIPS	2	46,100	56
2. GENERAL CARGO SHIPS	15	193,300	54
3. TANK SHIPS	6	219,400	25
4. TANK SHIPS	5	167,400	23
7. BULK CARRIERS	8	107,900	27
9. BULK CARRIERS - SELF-UNLOADERS	1	17,100	4
10. BULK CHEMICAL CARRIERS	1	25,600	4
12. CONTAINER/CARGO SHIPS	7	175,300	24
13. CONTAINER SHIPS (EXCLUSIVELY)	6	411,600	28
15. REFRIGERATED CARGO SHIPS	1	122,000	5
CASUALTY LOCATION TOTALS	52	1,485,700	250
HAWAII			
1. GENERAL CARGO SHIPS	1	60,500	2
3. TANK SHIPS	2	37,400	15
CASUALTY LOCATION TOTALS	3	97,900	17
PACIFIC CAL. TO PANAMA			
1. GENERAL CARGO SHIPS	1	64,500	2

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
2. GENERAL CARGO SHIPS	12	529,300	80
3. TANK SHIPS	1	9,200	3
4. TANK SHIPS	5	185,200	43
7. BULK CARRIERS	4	349,900	49
10. BULK CHEMICAL CARRIERS	1	8,500	3
15. REFRIGERATED CARGO SHIPS	2	20,800	7
CASUALTY LOCATION TOTALS	26	1,167,400	187
PACIFIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	48	1,314,800	259
4. TANK SHIPS	1	63,600	11
7. BULK CARRIERS	4	280,400	38
8. BULK CARRIERS - ORE/OIL	1	18,400	1
15. REFRIGERATED CARGO SHIPS	3	925,200	29
CASUALTY LOCATION TOTALS	57	2,602,400	338
ATLANTIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	3	13,800	12
4. TANK SHIPS	2	21,100	8
7. BULK CARRIERS	2	380,300	42
8. BULK CARRIERS - ORE/OIL	6	156,300	28
9. BULK CARRIERS - SELF-UNLOADERS	2	136,900	12
CASUALTY LOCATION TOTALS	15	708,400	102
GULF AND CARRIBBEAN			
1. GENERAL CARGO SHIPS	8	205,400	24
2. GENERAL CARGO SHIPS	64	1,246,100	283
3. TANK SHIPS	6	232,100	36
4. TANK SHIPS	39	2,272,700	317
7. BULK CARRIERS	50	1,711,100	262
8. BULK CARRIERS - ORE/OIL	4	128,600	23
9. BULK CARRIERS - SELF-UNLOADERS	5	225,400	28
10. BULK CHEMICAL CARRIERS	13	409,300	75
12. CONTAINER/CARGO SHIPS	3	34,200	34
13. CONTAINER SHIPS (EXCLUSIVELY)	4	200,700	46

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
15. REFRIGERATED CARGO SHIPS	4	58,900	22
16. PASSENGER SHIPS	2	73,500	11
19. BARGE CARRIERS	1	22,200	7
CASUALTY LOCATION TOTALS	203	6,820,200	1,168
SOUTH ATLANTIC US TIP			
2. GENERAL CARGO SHIPS	2	46,300	13
4. TANK SHIPS	2	205,600	9
7. BULK CARRIERS	2	70,200	7
CASUALTY LOCATION TOTALS	6	322,100	29
SOUTH ATLANTIC US			
1. GENERAL CARGO SHIPS	1	24,300	3
2. GENERAL CARGO SHIPS	7	132,800	29
3. TANK SHIPS	1	6,700	1
4. TANK SHIPS	6	216,900	17
5. TANK SHIPS	1	335,200	18
7. BULK CARRIERS	1	11,300	2
10. BULK CHEMICAL CARRIERS	1	175,000	10
11. LIQUID GAS CARRIERS	1	12,700	4
13. CONTAINER SHIPS (EXCLUSIVELY)	2	174,800	13
CASUALTY LOCATION TOTALS	21	1,089,700	97
US NORTH ATLANTIC			
1. GENERAL CARGO SHIPS	2	119,200	13
2. GENERAL CARGO SHIPS	26	576,500	99
3. TANK SHIPS	6	136,400	18
4. TANK SHIPS	23	1,383,300	131
7. BULK CARRIERS	23	535,400	113
8. BULK CARRIERS - ORE/OIL	1	6,300	3
10. BULK CHEMICAL CARRIERS	5	232,500	26
11. LIQUID GAS CARRIERS	1	4,400	4
13. CONTAINER SHIPS (EXCLUSIVELY)	5	131,000	22
15. REFRIGERATED CARGO SHIPS	1	27,500	8
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	18,400	5

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
CASUALTY LOCATION TOTALS	94	3,170,900	442
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	1	10,000	5
4. TANK SHIPS	2	50,500	16
7. BULK CARRIERS	2	32,100	14
CASUALTY LOCATION TOTALS	5	92,600	35
ST. LAWRENCE SEAWAY			
2. GENERAL CARGO SHIPS	19	563,100	130
4. TANK SHIPS	6	416,900	86
7. BULK CARRIERS	20	965,800	181
8. BULK CARRIERS - ORE/OIL	7	90,900	44
9. BULK CARRIERS - SELF-UNLOADERS	2	121,700	10
16. PASSENGER SHIPS	1	37,500	20
CASUALTY LOCATION TOTALS	55	2,195,900	471
GREAT LAKES			
2. GENERAL CARGO SHIPS	10	309,600	60
4. TANK SHIPS	3	18,800	15
7. BULK CARRIERS	95	2,786,100	508
8. BULK CARRIERS - ORE/OIL	5	137,900	27
9. BULK CARRIERS - SELF-UNLOADERS	40	1,004,100	217
16. PASSENGER SHIPS	1	14,000	6
CASUALTY LOCATION TOTALS	154	4,270,500	833
ATLANTIC EAST			
2. GENERAL CARGO SHIPS	2	63,200	4
4. TANK SHIPS	2	196,900	15
7. BULK CARRIERS	1	50,300	6
8. BULK CARRIERS - ORE/OIL	1	90,000	20
13. CONTAINER SHIPS (EXCLUSIVELY)	1	114,300	2

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
15. REFRIGERATED CARGO SHIPS	1	1,800	2
CASUALTY LOCATION TOTALS	8	516,500	49
ENGLAND			
2. GENERAL CARGO SHIPS	15	185,400	80
4. TANK SHIPS	24	419,500	124
5. TANK SHIPS	1	185,900	11
7. BULK CARRIERS	10	134,000	71
13. CONTAINER SHIPS (EXCLUSIVELY)	14	628,800	80
CASUALTY LOCATION TOTALS	64	1,553,600	366
NORTH SEA			
4. TANK SHIPS	2	41,800	13
10. BULK CHEMICAL CARRIERS	1	40,200	6
13. CONTAINER SHIPS (EXCLUSIVELY)	7	711,700	76
CASUALTY LOCATION TOTALS	10	793,700	95
BALTIC SEA			
1. GENERAL CARGO SHIPS	1	116,600	9
2. GENERAL CARGO SHIPS	4	139,300	23
4. TANK SHIPS	13	760,600	151
6. TANK SHIPS	1	34,200	6
7. BULK CARRIERS	7	229,800	42
11. LIQUID GAS CARRIERS	1	3,700	6
12. CONTAINER/CARGO SHIPS	1	20,700	4
13. CONTAINER SHIPS (EXCLUSIVELY)	2	77,800	6
15. REFRIGERATED CARGO SHIPS	1	10,300	4
19. BARGE CARRIERS	1	19,800	4
CASUALTY LOCATION TOTALS	32	1,412,800	255
WEST COAST OF EUROPE			
2. GENERAL CARGO SHIPS	22	359,300	114

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
3. TANK SHIPS	1	16,300	11
4. TANK SHIPS	29	900,600	210
6. TANK SHIPS	2	1,924,200	3
7. BULK CARRIERS	34	869,900	212
8. BULK CARRIERS - ORE/OIL	3	130,700	16
10. BULK CHEMICAL CARRIERS	2	30,000	7
12. CONTAINER/CARGO SHIPS	1	10,500	3
13. CONTAINER SHIPS (EXCLUSIVELY)	3	83,000	12
15. REFRIGERATED CARGO SHIPS	1	14,200	5
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	3	195,600	31
CASUALTY LOCATION TOTALS	101	4,534,300	694
EUROPE, MEDITER.			
2. GENERAL CARGO SHIPS	19	419,200	90
4. TANK SHIPS	14	937,100	103
6. TANK SHIPS	1	306,900	16
7. BULK CARRIERS	17	1,326,700	140
8. BULK CARRIERS - ORE/OIL	4	62,900	18
10. BULK CHEMICAL CARRIERS	1	29,000	3
12. CONTAINER/CARGO SHIPS	1	48,800	4
13. CONTAINER SHIPS (EXCLUSIVELY)	2	66,600	10
15. REFRIGERATED CARGO SHIPS	5	90,100	27
16. PASSENGER SHIPS	4	73,300	19
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	3	118,400	21
CASUALTY LOCATION TOTALS	71	3,479,000	451
AFRICA, MEDITER.			
2. GENERAL CARGO SHIPS	3	77,400	16
4. TANK SHIPS	1	38,200	5
7. BULK CARRIERS	3	76,700	23
8. BULK CARRIERS - ORE/OIL	1	34,400	4
CASUALTY LOCATION TOTALS	8	226,700	48
WEST AFRICA			
1. GENERAL CARGO SHIPS	1	17,300	3

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
2. GENERAL CARGO SHIPS	11	393,700	59
4. TANK SHIPS	4	169,300	15
7. BULK CARRIERS	8	218,400	44
8. BULK CARRIERS - ORE/OIL	1	998,400	29
19. BARGE CARRIERS	1	13,600	4
CASUALTY LOCATION TOTALS	26	1,810,700	154
TIP OF AFRICA			
2. GENERAL CARGO SHIPS	6	104,600	24
4. TANK SHIPS	3	90,000	27
7. BULK CARRIERS	1	2,500	3
15. REFRIGERATED CARGO SHIPS	1	29,000	5
CASUALTY LOCATION TOTALS	11	226,100	59
EAST OF AFRICA			
2. GENERAL CARGO SHIPS	6	120,100	36
4. TANK SHIPS	5	199,400	27
CASUALTY LOCATION TOTALS	11	319,500	63
PERSIAN GULF			
3. TANK SHIPS	2	55,400	17
4. TANK SHIPS	11	558,000	63
7. BULK CARRIERS	2	24,600	10
CASUALTY LOCATION TOTALS	15	638,000	90
SEA OF BENGAL			
1. GENERAL CARGO SHIPS	3	58,500	7
2. GENERAL CARGO SHIPS	9	68,200	36
4. TANK SHIPS	11	1,569,900	102
7. BULK CARRIERS	6	207,700	27
15. REFRIGERATED CARGO SHIPS	1	20,100	6
CASUALTY LOCATION TOTALS	30	1,924,400	178

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
INDONESIA			
1. GENERAL CARGO SHIPS	7	110,200	18
2. GENERAL CARGO SHIPS	40	1,384,200	241
3. TANK SHIPS	3	227,600	69
4. TANK SHIPS	5	203,000	42
5. TANK SHIPS	1	84,600	6
7. BULK CARRIERS	1	89,700	1
12. CONTAINER/CARGO SHIPS	3	43,500	7
13. CONTAINER SHIPS (EXCLUSIVELY)	1	15,000	6
CASUALTY LOCATION TOTALS	61	2,157,800	390
AUST/NZ			
2. GENERAL CARGO SHIPS	1	500	2
4. TANK SHIPS	3	73,400	17
7. BULK CARRIERS	6	369,900	41
CASUALTY LOCATION TOTALS	10	443,800	60
NORTH PACIFIC			
1. GENERAL CARGO SHIPS	3	82,200	6
2. GENERAL CARGO SHIPS	27	812,100	142
3. TANK SHIPS	1	18,600	4
4. TANK SHIPS	9	321,400	48
7. BULK CARRIERS	17	439,100	88
8. BULK CARRIERS - ORE/OIL	2	53,000	10
12. CONTAINER/CARGO SHIPS	6	534,800	40
13. CONTAINER SHIPS (EXCLUSIVELY)	3	237,400	10
15. REFRIGERATED CARGO SHIPS	1	3,600	2
19. BARGE CARRIERS	4	116,900	17
CASUALTY LOCATION TOTALS	73	2,619,100	367
2. GENERAL CARGO SHIPS	1	4,100	2

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
3. TANK SHIPS	2	71,400	10
4. TANK SHIPS	2	214,400	8
10. BULK CHEMICAL CARRIERS	2	19,400	3
12. CONTAINER/CARGO SHIPS	1	13,800	5
13. CONTAINER SHIPS (EXCLUSIVELY)	1	27,000	7
16. PASSENGER SHIPS	1	35,600	3
CASUALTY LOCATION TOTALS	10	385,700	38
ALLEGED CAUSE TOTALS	1,240	47,327,400	7,357

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
COLLISION - SHIP TO SHIP			
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	1	659,700	8
7. BULK CARRIERS	2	5,700	5
9. BULK CARRIERS - SELF-UNLOADERS	1	9,700	3
CASUALTY LOCATION TOTALS	4	675,100	16
US PACIFIC			
1. GENERAL CARGO SHIPS	1	5,200	2
2. GENERAL CARGO SHIPS	8	33,500	27
3. TANK SHIPS	4	36,600	12
4. TANK SHIPS	6	226,600	26
12. CONTAINER/CARGO SHIPS	3	95,400	8
13. CONTAINER SHIPS (EXCLUSIVELY)	2	145,800	19
19. BARGE CARRIERS	1	24,000	5
CASUALTY LOCATION TOTALS	25	567,100	99
HAWAII			
1. GENERAL CARGO SHIPS	3	11,500	8
2. GENERAL CARGO SHIPS	3	111,000	18
CASUALTY LOCATION TOTALS	6	122,500	26
PACIFIC CAL. TO PANAMA			
1. GENERAL CARGO SHIPS	1	28,400	5
3. TANK SHIPS	1	19,800	9
7. BULK CARRIERS	4	767,500	57
15. REFRIGERATED CARGO SHIPS	2	158,400	17
CASUALTY LOCATION TOTALS	8	974,100	88
PACIFIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	5	112,600	28
15. REFRIGERATED CARGO SHIPS	1	7,400	6

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT.
CASUALTY LOCATION TOTALS	6	120,000	34
ATLANTIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	4	35,900	24
4. TANK SHIPS	2	30,100	10
7. BULK CARRIERS	2	54,900	23
9. BULK CARRIERS - SELF-UNLOADERS	2	20,400	18
15. REFRIGERATED CARGO SHIPS	1	400	2
16. PASSENGER SHIPS	1	3,200	3
CASUALTY LOCATION TOTALS	12	144,900	80
GULF AND CARRIBBEAN			
1. GENERAL CARGO SHIPS	13	261,800	52
2. GENERAL CARGO SHIPS	66	2,314,200	409
3. TANK SHIPS	3	30,200	11
4. TANK SHIPS	31	8,393,300	411
6. TANK SHIPS	2	80,100	14
7. BULK CARRIERS	44	1,326,900	241
8. BULK CARRIERS - ORE/OIL	3	10,900	8
9. BULK CARRIERS - SELF-UNLOADERS	3	111,700	21
10. BULK CHEMICAL CARRIERS	8	111,500	24
11. LIQUID GAS CARRIERS	1	38,700	8
12. CONTAINER/CARGO SHIPS	2	175,000	35
13. CONTAINER SHIPS (EXCLUSIVELY)	5	94,400	18
15. REFRIGERATED CARGO SHIPS	7	102,600	25
19. BARGE CARRIERS	1	2,000	3
CASUALTY LOCATION TOTALS	189	13,053,300	1,280
SOUTH ATLANTIC US TIP			
1. GENERAL CARGO SHIPS	1	10,000	4
7. BULK CARRIERS	1	15,900	13
8. BULK CARRIERS - ORE/OIL	1	18,300	3
10. BULK CHEMICAL CARRIERS	1	35,500	5
CASUALTY LOCATION TOTALS	4	79,700	25

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
SOUTH ATLANTIC US			
1. GENERAL CARGO SHIPS	1	10,000	4
2. GENERAL CARGO SHIPS	5	4,091,300	205
3. TANK SHIPS	3	17,000	7
4. TANK SHIPS	1	32,800	3
13. CONTAINER SHIPS (EXCLUSIVELY)	1	470,700	15
15. REFRIGERATED CARGO SHIPS	1	106,500	14
CASUALTY LOCATION TOTALS	12	4,728,300	248
US NORTH ATLANTIC			
1. GENERAL CARGO SHIPS	2	1,900	2
2. GENERAL CARGO SHIPS	18	1,405,700	126
3. TANK SHIPS	7	198,700	36
4. TANK SHIPS	37	3,209,300	318
7. BULK CARRIERS	6	81,500	28
8. BULK CARRIERS - ORE/OIL	2	145,300	20
10. BULK CHEMICAL CARRIERS	2	33,800	10
12. CONTAINER/CARGO SHIPS	2	508,300	26
13. CONTAINER SHIPS (EXCLUSIVELY)	10	6,319,400	145
15. REFRIGERATED CARGO SHIPS	1	55,000	3
16. PASSENGER SHIPS	1	18,200	7
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	144,800	14
19. BARGE CARRIERS	2	31,600	9
CASUALTY LOCATION TOTALS	91	12,153,500	744
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	1	73,300	11
8. BULK CARRIERS - ORE/OIL	1	6,500	3
CASUALTY LOCATION TOTALS	2	79,800	14
ST. LAWRENCE SEAWAY			
2. GENERAL CARGO SHIPS	1	24,800	6

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3. TANK SHIPS	1	3,800	2
4. TANK SHIPS	1	26,100	4
7. BULK CARRIERS	1	103,000	8
CASUALTY LOCATION TOTALS	4	157,700	20
GREAT LAKES			
4. TANK SHIPS	2	7,100	7
7. BULK CARRIERS	17	1,243,300	112
9. BULK CARRIERS - SELF-UNLOADERS	8	128,700	32
CASUALTY LOCATION TOTALS	27	1,379,100	151
ATLANTIC EAST			
2. GENERAL CARGO SHIPS	1	9,100	3
CASUALTY LOCATION TOTALS	1	9,100	3
ENGLAND			
2. GENERAL CARGO SHIPS	1	292,500	18
4. TANK SHIPS	7	8,897,200	141
7. BULK CARRIERS	3	217,400	29
8. BULK CARRIERS - ORE/OIL	2	112,900	13
10. BULK CHEMICAL CARRIERS	1	15,400	5
12. CONTAINER/CARGO SHIPS	2	24,200	9
13. CONTAINER SHIPS (EXCLUSIVELY)	2	900	3
15. REFRIGERATED CARGO SHIPS	1	11,200	3
CASUALTY LOCATION TOTALS	19	9,571,700	221
NORTH SEA			
4. TANK SHIPS	1	6,700	4
7. BULK CARRIERS	1	40,300	5
13. CONTAINER SHIPS (EXCLUSIVELY)	1	11,700	6
CASUALTY LOCATION TOTALS	3	58,700	15

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT.
BALTIC SEA			
2. GENERAL CARGO SHIPS	5	205,000	38
4. TANK SHIPS	3	38,300	13
7. BULK CARRIERS	2	34,100	15
13. CONTAINER SHIPS (EXCLUSIVELY)	1	19,900	3
15. REFRIGERATED CARGO SHIPS	1	62,000	9
CASUALTY LOCATION TOTALS	12	359,300	78
WEST COAST OF EUROPE			
2. GENERAL CARGO SHIPS	3	23,700	12
3. TANK SHIPS	1	24,600	8
4. TANK SHIPS	9	328,000	49
7. BULK CARRIERS	16	486,700	122
8. BULK CARRIERS - ORE/OIL	3	195,400	27
12. CONTAINER/CARGO SHIPS	1	1,800	1
15. REFRIGERATED CARGO SHIPS	3	60,600	16
CASUALTY LOCATION TOTALS	36	1,120,800	235
EUROPE, MEDITER.			
1. GENERAL CARGO SHIPS	1	1,300	2
2. GENERAL CARGO SHIPS	10	26,600	26
4. TANK SHIPS	13	496,600	104
6. TANK SHIPS	1	11,600	3
7. BULK CARRIERS	3	12,500	13
8. BULK CARRIERS - ORE/OIL	3	43,900	16
12. CONTAINER/CARGO SHIPS	2	83,900	15
15. REFRIGERATED CARGO SHIPS	1	12,300	4
16. PASSENGER SHIPS	3	22,600	20
19. BARGE CARRIERS	2	70,100	15
CASUALTY LOCATION TOTALS	39	781,400	218
AFRICA, MEDITER.			
2. GENERAL CARGO SHIPS	2	1,500	3

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
CASUALTY LOCATION TOTALS	2	1,500	3
WEST AFRICA			
4. TANK SHIPS	2	21,900	9
7. BULK CARRIERS	4	13,800	10
CASUALTY LOCATION TOTALS	6	35,700	19
TIP OF AFRICA			
2. GENERAL CARGO SHIPS	7	219,200	50
4. TANK SHIPS	1	2,251,300	84
7. BULK CARRIERS	1	700	2
15. REFRIGERATED CARGO SHIPS	2	21,800	7
CASUALTY LOCATION TOTALS	11	2,493,000	143
EAST OF AFRICA			
4. TANK SHIPS	2	92,300	14
15. REFRIGERATED CARGO SHIPS	4	34,800	19
CASUALTY LOCATION TOTALS	6	127,100	33
PERSIAN GULF			
2. GENERAL CARGO SHIPS	1	16,200	2
4. TANK SHIPS	6	335,000	60
6. TANK SHIPS	1	1,445,000	51
8. BULK CARRIERS – ORE/OIL	2	6,017,100	12
CASUALTY LOCATION TOTALS	10	7,813,300	125
SEA OF BENGAL			
1. GENERAL CARGO SHIPS	3	92,800	11
2. GENERAL CARGO SHIPS	3	24,400	10

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
4. TANK SHIPS	10	2,571,600	136
7. BULK CARRIERS	4	97,500	19
CASUALTY LOCATION TOTALS	20	2,786,300	176
INDONESIA			
1. GENERAL CARGO SHIPS	16	245,800	64
2. GENERAL CARGO SHIPS	76	1,203,000	265
3. TANK SHIPS	7	187,200	35
4. TANK SHIPS	15	1,948,800	186
7. BULK CARRIERS	1	1,700	4
8. BULK CARRIERS - ORE/OIL	3	1,645,600	72
12. CONTAINER/CARGO SHIPS	4	161,300	25
16. PASSENGER SHIPS	1	65,500	6
CASUALTY LOCATION TOTALS	123	5,458,900	657
AUST/NZ			
1. GENERAL CARGO SHIPS	1	12,300	5
7. BULK CARRIERS	3	30,400	8
CASUALTY LOCATION TOTALS	4	42,700	13
NORTH PACIFIC			
1. GENERAL CARGO SHIPS	8	1,144,700	98
2. GENERAL CARGO SHIPS	48	2,246,500	274
3. TANK SHIPS	2	32,100	7
4. TANK SHIPS	6	312,900	50
7. BULK CARRIERS	16	888,300	129
8. BULK CARRIERS - ORE/OIL	1	74,100	15
12. CONTAINER/CARGO SHIPS	5	350,700	26
13. CONTAINER SHIPS (EXCLUSIVELY)	7	1,167,400	43
16. PASSENGER SHIPS	2	188,200	22
19. BARGE CARRIERS	2	24,700	9
CASUALTY LOCATION TOTALS	97	6,429,600	673

UNITED STATES SALVAGE ASSOCIATION, INC.
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BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
2. GENERAL CARGO SHIPS	3	62,600	19
4. TANK SHIPS	1	39,400	7
10. BULK CHEMICAL CARRIERS	2	31,400	7
CASUALTY LOCATION TOTALS	6	133,400	33
ALLEGED CAUSE TOTALS	785	71,457,600	5,470

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
HEAVY WEATHER DAMAGE			
ALASKA			
1. GENERAL CARGO SHIPS	1	86,000	4
2. GENERAL CARGO SHIPS	1	15,500	6
CASUALTY LOCATION TOTALS	2	101,500	10
CANADA PACIFIC			
4. TANK SHIPS	1	52,900	5
7. BULK CARRIERS	2	8,100	4
CASUALTY LOCATION TOTALS	3	61,000	9
US PACIFIC			
2. GENERAL CARGO SHIPS	2	47,600	17
3. TANK SHIPS	1	10,500	2
4. TANK SHIPS	1	7,900	3
7. BULK CARRIERS	1	33,000	2
12. CONTAINER/CARGO SHIPS	2	75,400	11
15. REFRIGERATED CARGO SHIPS	3	42,600	14
CASUALTY LOCATION TOTALS	10	217,000	49
HAWAII			
2. GENERAL CARGO SHIPS	1	39,100	8
4. TANK SHIPS	3	75,900	14
CASUALTY LOCATION TOTALS	4	115,000	22
PACIFIC CAL. TO PANAMA			
1. GENERAL CARGO SHIPS	1	21,200	4
2. GENERAL CARGO SHIPS	21	951,200	134
3. TANK SHIPS	1	7,400	4
4. TANK SHIPS	11	743,300	77
7. BULK CARRIERS	16	406,300	90
8. BULK CARRIERS - ORE/OIL	1	32,800	6

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
12. CONTAINER/CARGO SHIPS	5	95,900	28
13. CONTAINER SHIPS (EXCLUSIVELY)	5	150,600	31
15. REFRIGERATED CARGO SHIPS	4	78,200	16
19. BARGE CARRIERS	1	20,200	4
CASUALTY LOCATION TOTALS	66	2,507,100	394
PACIFIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	2	35,600	11
7. BULK CARRIERS	1	57,000	10
15. REFRIGERATED CARGO SHIPS	1	2,500	2
CASUALTY LOCATION TOTALS	4	95,100	23
SOUTH TIP OF SOUTH AMERICA			
4. TANK SHIPS	1	20,300	2
5. TANK SHIPS	1	86,600	11
7. BULK CARRIERS	1	25,100	22
8. BULK CARRIERS - ORE/OIL	2	75,000	19
CASUALTY LOCATION TOTALS	5	207,000	54
ATLANTIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	1	4,500	2
4. TANK SHIPS	1	8,500	3
8. BULK CARRIERS - ORE/OIL	2	22,800	10
CASUALTY LOCATION TOTALS	4	35,800	15
GULF AND CARRIBBEAN			
2. GENERAL CARGO SHIPS	8	100,100	28
4. TANK SHIPS	6	290,900	75
7. BULK CARRIERS	5	62,600	40
10. BULK CHEMICAL CARRIERS	1	10,100	8
15. REFRIGERATED CARGO SHIPS	2	28,000	4
CASUALTY LOCATION TOTALS	22	491,700	155

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT,
SOUTH ATLANTIC US TIP			
1. GENERAL CARGO SHIPS	3	148,100	29
2. GENERAL CARGO SHIPS	9	208,900	77
3. TANK SHIPS	1	3,600	3
4. TANK SHIPS	27	1,084,700	351
7. BULK CARRIERS	18	896,300	140
8. BULK CARRIERS - ORE/OIL	4	87,200	30
9. BULK CARRIERS - SELF-UNLOADERS	3	145,800	26
10. BULK CHEMICAL CARRIERS	1	47,300	10
12. CONTAINER/CARGO SHIPS	1	180,900	25
13. CONTAINER SHIPS (EXCLUSIVELY)	9	301,700	36
16. PASSENGER SHIPS	1	75,400	14
19. BARGE CARRIERS	2	61,100	14
CASUALTY LOCATION TOTALS	79	3,241,000	755
SOUTH ATLANTIC US			
2. GENERAL CARGO SHIPS	6	196,000	31
3. TANK SHIPS	1	48,000	6
4. TANK SHIPS	13	846,100	98
7. BULK CARRIERS	2	28,500	9
8. BULK CARRIERS - ORE/OIL	1	23,100	13
9. BULK CARRIERS - SELF-UNLOADERS	1	301,800	48
10. BULK CHEMICAL CARRIERS	1	10,000	3
CASUALTY LOCATION TOTALS	25	1,453,500	208
US NORTH ATLANTIC			
2. GENERAL CARGO SHIPS	1	4,200	2
4. TANK SHIPS	2	91,500	13
CASUALTY LOCATION TOTALS	3	95,700	15
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	1	9,100	5

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENT
4. TANK SHIPS	3	60,700	22
7. BULK CARRIERS	1	8,000	6
CASUALTY LOCATION TOTALS	5	77,800	33
ST. LAWRENCE SEAWAY			
2. GENERAL CARGO SHIPS	1	10,600	4
CASUALTY LOCATION TOTALS	1	10,600	4
GREAT LAKES			
4. TANK SHIPS	1	45,000	1
7. BULK CARRIERS	5	89,500	21
9. BULK CARRIERS - SELF-UNLOADERS	1	67,400	4
CASUALTY LOCATION TOTALS	7	201,900	26
ATLANTIC EAST			
1. GENERAL CARGO SHIPS	3	155,400	19
2. GENERAL CARGO SHIPS	16	298,900	136
3. TANK SHIPS	1	20,000	7
4. TANK SHIPS	27	1,426,300	278
6. TANK SHIPS	1	314,900	25
7. BULK CARRIERS	33	2,150,900	301
8. BULK CARRIERS - ORE/OIL	8	427,600	94
10. BULK CHEMICAL CARRIERS	4	150,900	23
13. CONTAINER SHIPS (EXCLUSIVELY)	10	361,200	74
15. REFRIGERATED CARGO SHIPS	4	105,600	20
CASUALTY LOCATION TOTALS	107	5,411,700	977
ENGLAND			
4. TANK SHIPS	3	555,100	48
8. BULK CARRIERS - ORE/OIL	2	63,600	19
9. BULK CARRIERS - SELF-UNLOADERS	1	40,600	8
12. CONTAINER/CARGO SHIPS	1	4,500	2

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
13. CONTAINER SHIPS (EXCLUSIVELY)	1	56,800	6
CASUALTY LOCATION TOTALS	8	720,600	63
NORTH SEA			
4. TANK SHIPS	4	151,000	15
7. BULK CARRIERS	1	73,100	11
12. CONTAINER/CARGO SHIPS	1		
13. CONTAINER SHIPS (EXCLUSIVELY)	1	194,600	7
CASUALTY LOCATION TOTALS	7	418,700	33
BALTIC SEA			
2. GENERAL CARGO SHIPS	1	364,000	85
4. TANK SHIPS	2	40,700	6
7. BULK CARRIERS	2	61,300	17
CASUALTY LOCATION TOTALS	5	466,000	108
WEST COAST OF EUROPE			
4. TANK SHIPS	6	285,800	40
7. BULK CARRIERS	2	21,400	7
8. BULK CARRIERS - ORE/OIL	1	11,800	12
CASUALTY LOCATION TOTALS	9	319,000	59
EUROPE, MEDITER.			
2. GENERAL CARGO SHIPS	5	185,400	58
4. TANK SHIPS	11	430,200	112
7. BULK CARRIERS	2	36,200	14
8. BULK CARRIERS - ORE/OIL	2	128,500	35
12. CONTAINER/CARGO SHIPS	1	177,400	21
15. REFRIGERATED CARGO SHIPS	1	4,200	8
16. PASSENGER SHIPS	1	7,000	2
CASUALTY LOCATION TOTALS	23	968,900	250

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
AFRICA, MEDITER.			
4. TANK SHIPS	4	149,700	31
CASUALTY LOCATION TOTALS	4	149,700	31
WEST AFRICA			
1. GENERAL CARGO SHIPS	1	47,800	5
2. GENERAL CARGO SHIPS	1	27,300	4
4. TANK SHIPS	7	875,800	161
6. TANK SHIPS	1	58,100	5
7. BULK CARRIERS	1	7,000	4
8. BULK CARRIERS - ORE/OIL	2	172,700	33
CASUALTY LOCATION TOTALS	13	1,188,700	212
TIP OF AFRICA			
1. GENERAL CARGO SHIPS	1	2,100	3
2. GENERAL CARGO SHIPS	7	240,800	45
4. TANK SHIPS	11	1,118,300	130
5. TANK SHIPS	1	45,900	6
6. TANK SHIPS	3	201,800	22
7. BULK CARRIERS	2	56,500	20
8. BULK CARRIERS - ORE/OIL	5	209,100	73
CASUALTY LOCATION TOTALS	30	1,874,500	299
EAST OF AFRICA			
2. GENERAL CARGO SHIPS	1	42,500	14
3. TANK SHIPS	1	6,400	6
4. TANK SHIPS	13	996,900	131
7. BULK CARRIERS	5	371,800	46
8. BULK CARRIERS - ORE/OIL	3	217,800	34
CASUALTY LOCATION TOTALS	23	1,635,400	231
PERSIAN GULF			

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
4. TANK SHIPS	7	422,900	76
7. BULK CARRIERS	1	14,800	2
8. BULK CARRIERS - ORE/OIL	1	107,000	9
CASUALTY LOCATION TOTALS	9	544,700	97
SEA OF BENGAL			
1. GENERAL CARGO SHIPS	1	14,700	2
7. BULK CARRIERS	1	66,800	9
CASUALTY LOCATION TOTALS	2	81,500	11
INDONESIA			
1. GENERAL CARGO SHIPS	3	95,600	10
2. GENERAL CARGO SHIPS	4	57,200	22
3. TANK SHIPS	1	59,900	6
4. TANK SHIPS	7	401,800	86
5. TANK SHIPS	1	90,100	12
7. BULK CARRIERS	2	83,800	18
12. CONTAINER/CARGO SHIPS	1	59,000	8
CASUALTY LOCATION TOTALS	19	847,400	162
AUST/NZ			
1. GENERAL CARGO SHIPS	1	12,500	4
2. GENERAL CARGO SHIPS	1	1,500	2
4. TANK SHIPS	1	364,000	40
7. BULK CARRIERS	4	187,400	29
15. REFRIGERATED CARGO SHIPS	2	10,500	4
CASUALTY LOCATION TOTALS	9	575,900	79
NORTH PACIFIC			
1. GENERAL CARGO SHIPS	3	81,500	45
2. GENERAL CARGO SHIPS	15	277,200	74

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
3. TANK SHIPS	1	76,000	12
4. TANK SHIPS	13	1,490,200	303
7. BULK CARRIERS	16	488,100	80
8. BULK CARRIERS - ORE/OIL	4	209,800	17
9. BULK CARRIERS - SELF-UNLOADERS	1	1,900	4
11. LIQUID GAS CARRIERS	1	120,800	38
12. CONTAINER/CARGO SHIPS	2	90,100	15
13. CONTAINER SHIPS (EXCLUSIVELY)	2	76,300	7
15. REFRIGERATED CARGO SHIPS	1	3,700	1
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	14,100	10
19. BARGE CARRIERS	2	34,800	10
CASUALTY LOCATION TOTALS	62	2,964,500	616
ALLEGED CAUSE TOTALS	570	27,078,900	5,020

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
ATERIAL FAILURE, VESSEL STRUCTURE AND EQUIPMENT			
CANADA PACIFIC			
4. TANK SHIPS	2	40,900	18
7. BULK CARRIERS	1	8,000	3
CASUALTY LOCATION TOTALS	3	48,900	21
US PACIFIC			
1. GENERAL CARGO SHIPS	2	26,000	10
2. GENERAL CARGO SHIPS	23	447,000	171
3. TANK SHIPS	6	255,300	54
4. TANK SHIPS	2	168,900	15
7. BULK CARRIERS	2	44,400	14
12. CONTAINER/CARGO SHIPS	6	183,800	37
13. CONTAINER SHIPS (EXCLUSIVELY)	5	656,600	38
17. RAILROAD CAR FERRIES	1	20,000	5
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	1,200	1
19. BARGE CARRIERS	3	745,200	41
CASUALTY LOCATION TOTALS	51	2,548,400	386
HAWAII			
1. GENERAL CARGO SHIPS	1	4,400	3
2. GENERAL CARGO SHIPS	1	5,500	2
12. CONTAINER/CARGO SHIPS	4	209,800	32
16. PASSENGER SHIPS	2	178,800	14
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	46,600	40
CASUALTY LOCATION TOTALS	9	445,100	91
PACIFIC CAL. TO PANAMA			
1. GENERAL CARGO SHIPS	2	44,300	22
2. GENERAL CARGO SHIPS	17	798,400	151
4. TANK SHIPS	3	216,100	24
7. BULK CARRIERS	3	185,200	14
12. CONTAINER/CARGO SHIPS	5	277,800	63
13. CONTAINER SHIPS (EXCLUSIVELY)	6	308,400	36
15. REFRIGERATED CARGO SHIPS	2	27,700	17

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
16. PASSENGER SHIPS	2	215,500	10
19. BARGE CARRIERS	2	617,400	90
CASUALTY LOCATION TOTALS	42	2,690,800	427
PACIFIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	1	93,500	10
7. BULK CARRIERS	2	105,600	22
CASUALTY LOCATION TOTALS	3	199,100	32
SOUTH TIP OF SOUTH AMERICA			
4. TANK SHIPS	5	160,300	78
7. BULK CARRIERS	1	4,200	5
CASUALTY LOCATION TOTALS	6	164,500	83
ATLANTIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	1	6,400	3
4. TANK SHIPS	5	199,700	123
7. BULK CARRIERS	3	48,400	15
8. BULK CARRIERS - ORE/OIL	1	18,400	3
19. BARGE CARRIERS	1	61,300	15
CASUALTY LOCATION TOTALS	11	334,200	159
GULF AND CARRIBBEAN			
1. GENERAL CARGO SHIPS	5	136,600	21
2. GENERAL CARGO SHIPS	26	560,000	169
3. TANK SHIPS	10	312,800	97
4. TANK SHIPS	24	1,081,300	215
7. BULK CARRIERS	11	208,500	103
8. BULK CARRIERS - ORE/OIL	1	13,600	8
9. BULK CARRIERS - SELF-UNLOADERS	5	508,200	39
10. BULK CHEMICAL CARRIERS	2	31,900	32
13. CONTAINER SHIPS (EXCLUSIVELY)	3	214,300	16

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15. REFRIGERATED CARGO SHIPS	2	43,000	14
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	49,200	1
19. BARGE CARRIERS	3	49,200	10
CASUALTY LOCATION TOTALS	93	3,208,600	725
SOUTH ATLANTIC US TIP			
2. GENERAL CARGO SHIPS	3	120,000	22
3. TANK SHIPS	3	151,200	28
4. TANK SHIPS	7	264,500	86
6. TANK SHIPS	1	71,000	7
7. BULK CARRIERS	4	131,200	22
8. BULK CARRIERS - ORE/OIL	1	38,900	18
12. CONTAINER/CARGO SHIPS	1	402,400	8
13. CONTAINER SHIPS (EXCLUSIVELY)	5	361,400	35
15. REFRIGERATED CARGO SHIPS	1	50,000	6
CASUALTY LOCATION TOTALS	26	1,590,600	232
SOUTH ATLANTIC US			
2. GENERAL CARGO SHIPS	7	434,400	52
3. TANK SHIPS	3	73,900	13
4. TANK SHIPS	7	196,600	66
7. BULK CARRIERS	3	237,400	23
10. BULK CHEMICAL CARRIERS	2	28,100	6
13. CONTAINER SHIPS (EXCLUSIVELY)	1	23,000	7
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	3	335,800	74
CASUALTY LOCATION TOTALS	26	1,329,200	241
US NORTH ATLANTIC			
1. GENERAL CARGO SHIPS	2	417,500	55
2. GENERAL CARGO SHIPS	1	67,500	9
3. TANK SHIPS	2	42,900	25
4. TANK SHIPS	11	337,100	80
5. TANK SHIPS	2	246,200	35
7. BULK CARRIERS	4	116,200	12
8. BULK CARRIERS - ORE/OIL	2	26,100	15

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
10. BULK CHEMICAL CARRIERS	3	75,800	22
11. LIQUID GAS CARRIERS	1	10,000	3
13. CONTAINER SHIPS (EXCLUSIVELY)	2	850,400	22
15. REFRIGERATED CARGO SHIPS	1	57,700	15
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	2	36,300	5
CASUALTY LOCATION TOTALS	33	2,283,700	298
CANADA PACIFIC			
4. TANK SHIPS	3	15,100	8
12. CONTAINER/CARGO SHIPS	1	6,000	5
CASUALTY LOCATION TOTALS	4	21,100	13
ST. LAWRENCE SEAWAY			
2. GENERAL CARGO SHIPS	2	65,800	14
7. BULK CARRIERS	1	5,700	4
9. BULK CARRIERS - SELF-UNLOADERS	1	198,400	10
CASUALTY LOCATION TOTALS	4	269,900	28
GREAT LAKES			
4. TANK SHIPS	4	93,000	32
7. BULK CARRIERS	6	113,600	48
9. BULK CARRIERS - SELF-UNLOADERS	9	256,000	75
CASUALTY LOCATION TOTALS	19	462,600	155
ATLANTIC EAST			
2. GENERAL CARGO SHIPS	4	229,200	47
3. TANK SHIPS	3	76,800	20
4. TANK SHIPS	16	851,800	192
7. BULK CARRIERS	5	524,400	51
8. BULK CARRIERS - ORE/OIL	1	136,000	10
9. BULK CARRIERS - SELF-UNLOADERS	1	18,200	3
13. CONTAINER SHIPS (EXCLUSIVELY)	2	1,171,800	29

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
15. REFRIGERATED CARGO SHIPS	2	10,800	7
19. BARGE CARRIERS	1	19,700	2
CASUALTY LOCATION TOTALS	35	3,038,700	361
ENGLAND			
2. GENERAL CARGO SHIPS	3	59,800	33
4. TANK SHIPS	7	380,700	87
13. CONTAINER SHIPS (EXCLUSIVELY)	2	334,400	23
CASUALTY LOCATION TOTALS	12	774,900	143
NORTH SEA			
2. GENERAL CARGO SHIPS	1	21,000	12
4. TANK SHIPS	1	12,400	3
CASUALTY LOCATION TOTALS	2	33,400	15
BALTIC SEA			
1. GENERAL CARGO SHIPS	2	156,200	17
2. GENERAL CARGO SHIPS	1	39,200	5
4. TANK SHIPS	2	23,500	10
7. BULK CARRIERS	1	28,200	2
8. BULK CARRIERS - ORE/OIL	1	21,200	2
13. CONTAINER SHIPS (EXCLUSIVELY)	1	7,900	5
15. REFRIGERATED CARGO SHIPS	2	51,700	11
CASUALTY LOCATION TOTALS	10	327,900	52
WEST COAST OF EUROPE			
2. GENERAL CARGO SHIPS	5	413,800	90
3. TANK SHIPS	1	10,800	7
4. TANK SHIPS	21	1,230,800	162
5. TANK SHIPS	1	22,500	6
6. TANK SHIPS	2	168,200	17
7. BULK CARRIERS	2	68,300	17

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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
8. BULK CARRIERS - ORE/OIL	3	148,500	23
13. CONTAINER SHIPS (EXCLUSIVELY)	1	33,300	11
15. REFRIGERATED CARGO SHIPS	1	12,800	5
CASUALTY LOCATION TOTALS	37	2,109,000	337
EUROPE, MEDITER.			
2. GENERAL CARGO SHIPS	6	132,700	78
4. TANK SHIPS	23	794,200	238
7. BULK CARRIERS	3	80,700	15
8. BULK CARRIERS - ORE/OIL	4	269,700	35
15. REFRIGERATED CARGO SHIPS	4	69,500	38
16. PASSENGER SHIPS	3	369,800	31
19. BARGE CARRIERS	2	1,060,400	18
CASUALTY LOCATION TOTALS	45	2,777,000	453
AFRICA, MEDITER.			
4. TANK SHIPS	2	120,500	15
CASUALTY LOCATION TOTALS	2	120,500	15
WEST AFRICA			
2. GENERAL CARGO SHIPS	3	55,700	12
4. TANK SHIPS	8	141,500	71
8. BULK CARRIERS - ORE/OIL	2	8,000	13
15. REFRIGERATED CARGO SHIPS	1	59,300	15
CASUALTY LOCATION TOTALS	14	264,500	111
TIP OF AFRICA			
1. GENERAL CARGO SHIPS	1	44,200	12
2. GENERAL CARGO SHIPS	1	18,700	10
4. TANK SHIPS	11	341,500	79
CASUALTY LOCATION TOTALS	13	404,400	101

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
EAST OF AFRICA			
2. GENERAL CARGO SHIPS	4	114,900	27
4. TANK SHIPS	10	978,900	174
6. TANK SHIPS	1	18,500	3
7. BULK CARRIERS	4	147,500	33
8. BULK CARRIERS - ORE/OIL	1	19,100	5
CASUALTY LOCATION TOTALS	20	1,278,900	242
PERSIAN GULF			
2. GENERAL CARGO SHIPS	1	40,300	6
3. TANK SHIPS	1	2,900	8
4. TANK SHIPS	13	4,268,200	245
6. TANK SHIPS	3	230,900	42
8. BULK CARRIERS - ORE/OIL	4	41,600	8
CASUALTY LOCATION TOTALS	22	4,583,900	309
SEA OF BENGAL			
1. GENERAL CARGO SHIPS	2	426,800	26
2. GENERAL CARGO SHIPS	5	60,800	20
4. TANK SHIPS	4	36,900	18
7. BULK CARRIERS	2	148,800	24
CASUALTY LOCATION TOTALS	13	673,300	88
INDONESIA			
2. GENERAL CARGO SHIPS	8	508,300	82
3. TANK SHIPS	2	84,300	12
4. TANK SHIPS	8	335,500	143
7. BULK CARRIERS	3	24,700	11
8. BULK CARRIERS - ORE/OIL	2	110,500	10
13. CONTAINER SHIPS (EXCLUSIVELY)	1	57,800	6
15. REFRIGERATED CARGO SHIPS	2	69,600	64
CASUALTY LOCATION TOTALS	26	1,190,700	328

UNITED STATES SALVACE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGEC CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
AUST/NZ			
4. TANK SHIPS	1	2,500	2
7. BULK CARRIERS	8	148,900	64
CASUALTY LOCATION TOTALS	9	151,400	66
NORTH PACIFIC			
2. GENERAL CARGO SHIPS	24	516,900	174
3. TANK SHIPS	1	5,000	4
4. TANK SHIPS	9	604,300	144
7. BULK CARRIERS	8	79,700	43
8. BULK CARRIERS - ORE/OIL	1	22,400	5
12. CONTAINER/CARGO SHIPS	7	313,800	35
13. CONTAINER SHIPS (EXCLUSIVELY)	7	259,600	28
15. REFRIGERATED CARGO SHIPS	6	155,200	60
19. BARGE CARRIERS	5	573,100	68
CASUALTY LOCATION TOTALS	68	2,530,000	561
4. TANK SHIPS	2	43,000	18
10. BULK CHEMICAL CARRIERS	3	121,900	31
11. LIQUID GAS CARRIERS	1	113,100	8
CASUALTY LOCATION TOTALS	6	278,000	57
ALLEGED CAUSE TOTALS	664	36,133,200	6,130

UNITED STATES SALVAGE ASSOCIATION, INC.
DAMAGE SURVEY ANALYSIS
BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
L OTHERS			
ALASKA			
1. GENERAL CARGO SHIPS	1	17,300	13
3. TANK SHIPS	2	41,700	5
4. TANK SHIPS	3	1,623,800	137
7. BULK CARRIERS	1	14,400	1
CASUALTY LOCATION TOTALS	7	1,697,200	156
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	6	888,900	28
4. TANK SHIPS	2	90,900	23
7. BULK CARRIERS	2	80,100	24
9. BULK CARRIERS - SELF-UNLOADERS	1	30,000	6
12. CONTAINER/CARGO SHIPS	2	34,400	10
CASUALTY LOCATION TOTALS	13	1,124,300	91
US PACIFIC			
1. GENERAL CARGO SHIPS	3	36,500	15
2. GENERAL CARGO SHIPS	17	373,900	86
3. TANK SHIPS	9	194,900	46
4. TANK SHIPS	9	1,966,900	82
7. BULK CARRIERS	3	104,900	17
9. BULK CARRIERS - SELF-UNLOADERS	2	27,900	8
12. CONTAINER/CARGO SHIPS	15	700,000	133
13. CONTAINER SHIPS (EXCLUSIVELY)	7	417,900	67
16. PASSENGER SHIPS	1	11,400	6
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	18,700	10
19. BARGE CARRIERS	2	62,000	14
CASUALTY LOCATION TOTALS	69	3,915,000	484
HAWAII			
1. GENERAL CARGO SHIPS	1	104,300	10
2. GENERAL CARGO SHIPS	4	126,500	10
3. TANK SHIPS	1	1,300	
4. TANK SHIPS	1	693,500	76

UNITED STATES SALVAGE ASSOCIATION, INC.
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JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
12. CONTAINER/CARGO SHIPS	1	27,000	
13. CONTAINER SHIPS (EXCLUSIVELY)	2	47,600	8
16. PASSENGER SHIPS	1	14,500	1
CASUALTY LOCATION TOTALS	11	1,014,700	105
PACIFIC CAL. TO PANAMA			
1. GENERAL CARGO SHIPS	2	29,900	12
2. GENERAL CARGO SHIPS	8	129,800	61
3. TANK SHIPS	2	232,100	37
4. TANK SHIPS	4	247,300	41
7. BULK CARRIERS	7	471,200	53
8. BULK CARRIERS - ORE/OIL	2	817,300	30
10. BULK CHEMICAL CARRIERS	1	40,700	9
12. CONTAINER/CARGO SHIPS	2	75,700	12
13. CONTAINER SHIPS (EXCLUSIVELY)	2	49,600	14
15. REFRIGERATED CARGO SHIPS	2	158,500	19
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	212,800	24
19. BARGE CARRIERS	1	916,200	102
CASUALTY LOCATION TOTALS	34	3,381,100	414
PACIFIC SOUTH AMERICA			
2. GENERAL CARGO SHIPS	11	533,300	91
4. TANK SHIPS	2	403,300	58
7. BULK CARRIERS	1	27,700	6
13. CONTAINER SHIPS (EXCLUSIVELY)	1	375,700	30
15. REFRIGERATED CARGO SHIPS	4	4,614,900	74
CASUALTY LOCATION TOTALS	19	5,954,900	259
SOUTH TIP OF SOUTH AMERICA			
2. GENERAL CARGO SHIPS	2	444,700	52
4. TANK SHIPS	3	48,500	26
7. BULK CARRIERS	1	20,100	3
9. BULK CARRIERS - SELF-UNLOADERS	1	20,000	3
16. PASSENGER SHIPS	1	3,500	3
CASUALTY LOCATION TOTALS	8	536,800	92

UNITED STATES SALVAGE ASSOCIATION, INC.
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JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
ATLANTIC SOUTH AMERICA			
1. GENERAL CARGO SHIPS	1	6,900	4
2. GENERAL CARGO SHIPS	11	248,300	74
4. TANK SHIPS	4	99,000	64
7. BULK CARRIERS	4	152,600	19
8. BULK CARRIERS - ORE/OIL	3	385,800	37
9. BULK CARRIERS - SELF-UNLOADERS	2	862,600	63
15. REFRIGERATED CARGO SHIPS	3	41,800	8
16. PASSENGER SHIPS	2	7,400	1
CASUALTY LOCATION TOTALS	30	1,804,400	270
GULF AND CARRIBBEAN			
1. GENERAL CARGO SHIPS	12	609,300	84
2. GENERAL CARGO SHIPS	68	2,152,800	243
3. TANK SHIPS	5	204,500	16
4. TANK SHIPS	72	3,884,500	810
6. TANK SHIPS	1	185,000	10
7. BULK CARRIERS	45	4,268,800	469
8. BULK CARRIERS - ORE/OIL	6	142,800	26
9. BULK CARRIERS - SELF-UNLOADERS	5	3,070,400	293
10. BULK CHEMICAL CARRIERS	9	252,400	86
12. CONTAINER/CARGO SHIPS	4	129,700	13
13. CONTAINER SHIPS (EXCLUSIVELY)	7	526,400	29
15. REFRIGERATED CARGO SHIPS	7	114,500	20
16. PASSENGER SHIPS	2	21,200	15
19. BARGE CARRIERS	3	107,800	20
CASUALTY LOCATION TOTALS	246	15,670,100	2,134
SOUTH ATLANTIC US TIP			
1. GENERAL CARGO SHIPS	1	95,500	14
2. GENERAL CARGO SHIPS	7	416,000	4[illegible]
4. TANK SHIPS	16	1,872,700	218
7. BULK CARRIERS	11	632,600	106
8. BULK CARRIERS - ORE/OIL	3	147,600	27
9. BULK CARRIERS - SELF-UNLOADERS	1	14,000	14

UNITED STATES SALVAGE ASSOCIATION, INC.
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JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
10. BULK CHEMICAL CARRIERS	2	514,200	46
11. LIQUID GAS CARRIERS	1	12,000	10
13. CONTAINER SHIPS (EXCLUSIVELY)	5	728,300	50
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	300,900	6
CASUALTY LOCATION TOTALS	48	4,733,800	540
SOUTH ATLANTIC US			
1. GENERAL CARGO SHIPS	8	512,200	59
2. GENERAL CARGO SHIPS	9	2,861,200	57
3. TANK SHIPS	2	265,700	15
4. TANK SHIPS	13	1,638,700	162
7. BULK CARRIERS	8	130,000	35
9. BULK CARRIERS - SELF-UNLOADERS	1	183,600	8
10. BULK CHEMICAL CARRIERS	2	130,800	27
13. CONTAINER SHIPS (EXCLUSIVELY)	3	3,469,800	10
15. REFRIGERATED CARGO SHIPS	2	181,200	8
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	22,000	3
19. BARGE CARRIERS	2	19,900	10
CASUALTY LOCATION TOTALS	51	9,415,300	394
US NORTH ATLANTIC			
1. GENERAL CARGO SHIPS	5	467,100	53
2. GENERAL CARGO SHIPS	14	1,376,700	87
3. TANK SHIPS	3	61,500	1
4. TANK SHIPS	46	6,202,300	364
7. BULK CARRIERS	15	820,200	123
8. BULK CARRIERS - ORE/OIL	4	375,800	12
9. BULK CARRIERS - SELF-UNLOADERS	3	78,200	20
10. BULK CHEMICAL CARRIERS	4	227,400	18
11. LIQUID GAS CARRIERS	1	6,000	10
12. CONTAINER/CARGO SHIPS	4	400,100	6
13. CONTAINER SHIPS (EXCLUSIVELY)	9	3,319,100	83
15. REFRIGERATED CARGO SHIPS	1	20,600	
16. PASSENGER SHIPS	1	145,900	10
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	86,200	
19. BARGE CARRIERS	2	55,700	7
CASUALTY LOCATION TOTALS	113	13,642,800	794

UNITED STATES SALVAGE ASSOCIATION, INC.
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JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
CANADA PACIFIC			
2. GENERAL CARGO SHIPS	5	351,000	63
3. TANK SHIPS	1	1,200	
4. TANK SHIPS	6	901,100	95
7. BULK CARRIERS	16	1,659,200	175
8. BULK CARRIERS - ORE/OIL	2	469,590	25
9. BULK CARRIERS - SELF-UNLOADERS	2	40,500	12
15. REFRIGERATED CARGO SHIPS	2	1,171,400	20
CASUALTY LOCATION TOTALS	34	4,593,900	390
ST. LAWRENCE SEAWAY			
2. GENERAL CARGO SHIPS	7	227,400	36
3. TANK SHIPS	1	3,400	
4. TANK SHIPS	9	980,300	100
7. BULK CARRIERS	11	464,800	72
8. BULK CARRIERS - ORE/OIL	1	600	1
9. BULK CARRIERS - SELF-UNLOADERS	3	123,600	25
CASUALTY LOCATION TOTALS	32	1,800,100	234
GREAT LAKES			
2. GENERAL CARGO SHIPS	1	20,600	5
4. TANK SHIPS	2	19,800	
7. BULK CARRIERS	47	2,602,500	261
9. BULK CARRIERS - SELF-UNLOADERS	13	1,805,200	333
CASUALTY LOCATION TOTALS	63	4,448,100	599
ATLANTIC EAST			
1. GENERAL CARGO SHIPS	1	171,000	10
2. GENERAL CARGO SHIPS	5	447,900	165
4. TANK SHIPS	15	1,804,900	298
6. TANK SHIPS	1	182,200	2
7. BULK CARRIERS	11	1,758,000	216

UNITED STATES SALVAGE ASSOCIATION, INC.
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BY ALLEGED CAUSE, CASUALTY LOCATION, AND VESSEL TYPE
JANUARY 1971 TO DECEMBER 1974

VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
8. BULK CARRIERS - ORE/OIL	6	961,400	116
9. BULK CARRIERS - SELF-UNLOADERS	2	163,300	26
10. BULK CHEMICAL CARRIERS	2	92,000	10
13. CONTAINER SHIPS (EXCLUSIVELY)	1	43,500	19
15. REFRIGERATED CARGO SHIPS	3	136,300	27
19. BARGE CARRIERS	1	104,900	15
CASUALTY LOCATION TOTALS	48	5,865,400	905
ENGLAND			
2. GENERAL CARGO SHIPS	5	141,600	44
4. TANK SHIPS	15	882,500	148
5. TANK SHIPS	1	65,800	33
7. BULK CARRIERS	6	226,500	51
8. BULK CARRIERS - ORE/OIL	3	160,500	39
10. BULK CHEMICAL CARRIERS	1	2,100	3
13. CONTAINER SHIPS (EXCLUSIVELY)	5	57,200	13
15. REFRIGERATED CARGO SHIPS	1	22,200	
CASUALTY LOCATION TOTALS	37	1,558,400	331
NORTH SEA			
4. TANK SHIPS	2	161,200	35
7. BULK CARRIERS	4	388,700	45
CASUALTY LOCATION TOTALS	6	549,900	80
BALTIC SEA			
1. GENERAL CARGO SHIPS	1	16,000	2
2. GENERAL CARGO SHIPS	7	646,500	22
4. TANK SHIPS	10	690,600	159
7. BULK CARRIERS	7	387,000	68
11. LIQUID GAS CARRIERS	2	7,800	16
13. CONTAINER SHIPS (EXCLUSIVELY)	3	475,500	12
15. REFRIGERATED CARGO SHIPS	4	110,800	12
CASUALTY LOCATION TOTALS	34	2,334,200	291

WEST COAST OF EUROPE

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
2. GENERAL CARGO SHIPS	15	634,200	102
3. TANK SHIPS	1	21,500	
4. TANK SHIPS	22	7,557,800	403
6. TANK SHIPS	1	33,700	10
7. BULK CARRIERS	32	1,284,200	184
8. BULK CARRIERS - ORE/OIL	3	373,600	49
9. BULK CARRIERS - SELF-UNLOADERS	2	44,600	15
10. BULK CHEMICAL CARRIERS	4	777,600	54
13. CONTAINER SHIPS (EXCLUSIVELY)	1	26,800	3
15. REFRIGERATED CARGO SHIPS	4	68,100	5
18. AUTOMOBILE, ROLL-ON/ROLL-OFF CARRIERS	1	30,000	10
19. BARGE CARRIERS	1	11,200	6
CASUALTY LOCATION TOTALS	87	10,863,300	841
EUROPE, MEDITER.			
2. GENERAL CARGO SHIPS	17	313,200	146
4. TANK SHIPS	47	4,291,700	1,034
6. TANK SHIPS	1	141,400	7
7. BULK CARRIERS	11	433,800	83
8. BULK CARRIERS - ORE/OIL	7	15,143,300	138
12. CONTAINER/CARGO SHIPS	3	30,500	10
15. REFRIGERATED CARGO SHIPS	2	33,400	7
16. PASSENGER SHIPS	5	37,300	15
19. BARGE CARRIERS	3	1,321,800	79
CASUALTY LOCATION TOTALS	96	21,746,400	1,519
AFRICA, MEDITER.			
2. GENERAL CARGO SHIPS	3	27,900	
4. TANK SHIPS	3	91,500	12
8. BULK CARRIERS - ORE/OIL	2	99,700	11
CASUALTY LOCATION TOTALS	8	219,100	23
WEST AFRICA			
1. GENERAL CARGO SHIPS	1	39,200	4

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
2. GENERAL CARGO SHIPS	4	34,400	13
4. TANK SHIPS	9	1,047,800	171
6. TANK SHIPS	3	11,708,600	142
7. BULK CARRIERS	5	62,800	18
8. BULK CARRIERS - ORE/OIL	3	183,900	24
15. REFRIGERATED CARGO SHIPS	1	21,700	4
16. PASSENGER SHIPS	1	24,600	4
CASUALTY LOCATION TOTALS	27	13,123,000	380
TIP OF AFRICA			
1. GENERAL CARGO SHIPS	1	1,600	2
2. GENERAL CARGO SHIPS	14	564,000	144
4. TANK SHIPS	10	6,892,800	263
6. TANK SHIPS	1	27,300	10
7. BULK CARRIERS	4	117,200	17
8. BULK CARRIERS - ORE/OIL	3	11,244,600	139
11. LIQUID GAS CARRIERS	1	161,000	20
15. REFRIGERATED CARGO SHIPS	1	3,000	1
CASUALTY LOCATION TOTALS	35	19,011,500	596
EAST OF AFRICA			
2. GENERAL CARGO SHIPS	7	172,800	62
4. TANK SHIPS	20	1,831,200	321
5. TANK SHIPS	2	113,900	25
7. BULK CARRIERS	1	400	1
8. BULK CARRIERS - ORE/OIL	2	109,800	18
15. REFRIGERATED CARGO SHIPS	1	14,000	8
CASUALTY LOCATION TOTALS	33	2,242,100	435
PERSIAN GULF			
2. GENERAL CARGO SHIPS	2	9,000	3
4. TANK SHIPS	12	3,076,400	270
5. TANK SHIPS	2	146,500	32
6. TANK SHIPS	3	1,096,200	136
7. BULK CARRIERS	1	83,700	15

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
8. BULK CARRIERS - ORE/OIL	3	1,165,300	10
CASUALTY LOCATION TOTALS	23	5,577,100	466
SEA OF BENGAL			
1. GENERAL CARGO SHIPS	1	34,700	25
2. GENERAL CARGO SHIPS	5	195,200	23
4. TANK SHIPS	12	1,777,200	101
5. TANK SHIPS	1	92,800	12
7. BULK CARRIERS	3	35,900	7
8. BULK CARRIERS - ORE/OIL	1	2,369,300	
CASUALTY LOCATION TOTALS	23	4,505,100	168
INDONESIA			
1. GENERAL CARGO SHIPS	7	420,500	51
2. GENERAL CARGO SHIPS	39	2,200,400	323
3. TANK SHIPS	2	2,800	6
4. TANK SHIPS	24	3,715,300	358
5. TANK SHIPS	4	233,800	76
7. BULK CARRIERS	3	15,400	6
8. BULK CARRIERS - ORE/OIL	3	45,800	9
12. CONTAINER/CARGO SHIPS	4	130,300	25
15. REFRIGERATED CARGO SHIPS	4	97,700	26
19. BARGE CARRIERS	3	466,600	23
CASUALTY LOCATION TOTALS	93	7,328,600	903
AUST/NZ			
1. GENERAL CARGO SHIPS	1	54,600	18
2. GENERAL CARGO SHIPS	2	36,500	9
4. TANK SHIPS	2	91,600	20
7. BULK CARRIERS	4	19,000	7
11. LIQUID GAS CARRIERS	1	96,000	8
12. CONTAINER/CARGO SHIPS	3	136,000	18
15. REFRIGERATED CARGO SHIPS	4	121,500	31
CASUALTY LOCATION TOTALS	17	555,200	111

UNITED STATES SALVAGE ASSOCIATION, INC.
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VESSEL TYPE	NUMBER OF CASUALTIES	TOTAL ACTUAL REPAIR COSTS	REPAIR TIME FOR AFFECTED ELEMENTS
NORTH PACIFIC			
1. GENERAL CARGO SHIPS	9	506,600	83
2. GENERAL CARGO SHIPS	61	2,482,500	256
4. TANK SHIPS	24	2,412,200	224
5. TANK SHIPS	3	1,009,400	173
6. TANK SHIPS	1	155,600	21
7. BULK CARRIERS	37	2,579,500	265
8. BULK CARRIERS – ORE/OIL	6	232,900	64
12. CONTAINER/CARGO SHIPS	9	137,500	36
13. CONTAINER SHIPS (EXCLUSIVELY)	5	465,800	3
15. REFRIGERATED CARGO SHIPS	4	54,100	25
16. PASSENGER SHIPS	1	35,700	3
19. BARGE CARRIERS	2	25,100	26
CASUALTY LOCATION TOTALS	162	10,096,900	1,179
1. GENERAL CARGO SHIPS	1	44,900	5
2. GENERAL CARGO SHIPS	3	13,400	6
4. TANK SHIPS	2	46,400	4
7. BULK CARRIERS	1	21,900	6
10. BULK CHEMICAL CARRIERS	3	21,900	6
19. BARGE CARRIERS	1	105,600	6
CASUALTY LOCATION TOTALS	11	254,100	33
ALLEGED CAUSE TOTALS	1,518	170,562,800	15,217
OVERALL TOTALS	5,452	449,402,400	45,065

APPENDIX G

Ocean Crossing Times - Routed and Unrouted Vessels

WEST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Westbound-Pacific Northwest to Japan	Tanker	INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA	
	Freighter	4855/276	4220/238	4850/277	4225/233	4635/252	4220/228	4525/242	4215/225
	Container	4720/229	4200/203	4785/233	4230/200	4520/211	4225/197	4500/207	4220/194
	Dry Bulk	4800/366	4235/321	4880/375	4240/312	4725/340	4225/302	4635/326	4230/298
Eastbound-Japan to Pacific Northwest	Tanker	INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA	
	Freighter	4320/230	4295/228	4300/232	4330/232	4205/221	4150/217	4125/217	4100/216
	Container	4235/194	4280/196	4315/199	4305/198	4185/189	4090/185	4090/186	4075/185
	Dry Bulk	4395/307	4325/302	4420/310	4320/304	4300/295	4245/291	4235/292	4195/289

Sample Count:

Routed Vessels 2520

Unrouted Vessels 1152

WEST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Westbound –									
Pacific North-west to Japan	Tanker	INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA	
	Freighter	21/16.68	45/4.62	39/18.38	55/3.89	39/17.14	39/8.33	59/14.05	42/4.45
	Container	5/9.97	39/6.69	4/10.69	40/10.14	6/9.77	39/8.11	6/9.80	36/7.92
	Dry Bulk	102/19.91	218/13.74	70/19.57	270/19.14	99/18.69	228/17.81	103/15.60	139/14.72
Eastbound –									
Japan to Pacific Northwest	Tanker	INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA		INSUFFICIENT DATA	
	Freighter	27/15.90	59/15.62	30/13.86	73/13.22	29/17.71	62/14.41	43/15.22	40/14.14
	Container	5/9.40	49/9.46	4/7.46	54/9.14	6/9.53	49/8.46	8/7.86	47/7.60
	Dry Bulk	109/14.53	214/15.36	96/16.06	236/15.11	109/16.86	218/16.50	131/16.88	179/16.38

n = sample size
s = standard deviation

Sample Count:
Routed Vessels 2520
Unrouted Vessels 1152

WEST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Westbound- California to Japan	Tanker	4920/349	4800/338	5230/374	5020/356	4915/334	4820/328	4775/323	4720/320
	Freighter	4775/262	4750/261	4993/279	4900/271	4805/236	4730/252	4595/243	4620/244
	Container	4620/221	4710/222	4920/241	4850/237	4735/216	4695/214	4605/208	4540/205
	Dry Bulk	4850/354	4790/350	5760/379	4985/367	5010/350	4905/345	4735/327	4695/324
Eastbound- Japan to California	Tanker	4815/330	4700/324	5025/335	4900/327	4635/311	4620/308	4635/307	4610/305
	Freighter	4715/249	4680/248	4635/245	4655/243	4530/237	4535/237	4520/235	4535/236
	Container	4585/207	4550/206	4600/211	4650/210	4525/204	4515/203	4510/203	4560/202
	Dry Bulk	4725/321	4640/320	4795/331	4730/326	4645/318	4575/316	4620/312	4595/310

Sample Count:

Routed Vessels 1224

Unrouted Vessels 432

WEST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Westbound –									
California to Japan	Tanker	14/12.91	39/13.98	12/21.03	48/15.96	16/16.00	42/15.44	18/15.91	33/15.64
	Freighter	19/12.76	43/12.24	10/16.24	48/19.48	18/12.96	41/13.17	23/13.96	39/13.55
	Container	5/10.49	29/15.56	3/8.08	32/17.93	4/9.74	31/11.36	7/14.68	29/15.48
	Dry Bulk	15/24.98	38/27.01	9/29.17	37/35.18	14/23.40	39/20.85	14/17.35	34/16.60
Eastbound –									
Japan to California	Tanker	19/14.10	41/12.01	14/22.67	46/19.29	18/17.20	42/17.35	29/13.75	36/11.39
	Freighter	18/17.56	48/15.15	15/17.10	53/15.11	15/10.68	50/9.54	26/13.95	42/12.46
	Container	4/9.50	31/14.18	3/5.86	33/15.58	4/9.71	31/14.30	6/9.67	30/16.17
	Dry Bulk	15/23.70	32/23.07	13/30.07	39/27.99	14/20.66	33/20.37	19/27.24	30/26.17

n = sample size

s = standard deviation

Sample Count:

Routed Vessels 1224

Unrouted Vessels 432

CANAL ZONE TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Westbound-Balboa to Japan	Tanker	7940/533	7985/531	8265/555	8515/546	8030/532	7915/524	7925/525	7900/523
	Freighter	7935/420	7895/418	7925/426	7985/422	7925/417	7835/412	7800/410	7795/410
	Container	7865/359	7840/358	7865/366	7955/363	7830/356	7810/355	7750/354	7770/352
	Dry Bulk	8000/556	7935/551	8205/568	8110/567	7995/548	7900/541	7890/540	7805/538
Eastbound-Japan to Balboa	Tanker	7935/540	7785/522	8165/552	7900/527	7800/516	7730/512	7705/507	7665/504
	Freighter	7780/409	7750/408	7900/418	7830/412	7745/410	7700/407	7690/408	7660/403
	Container	7735/350	7745/352	7775/357	7795/354	7665/345	7670/345	7655/346	7630/342
	Dry Bulk	7920/554	7775/540	8035/558	7890/544	7780/533	7735/530	7730/529	7660/521

Sample Count:

Routed Vessels 1116

Unrouted Vessels 792

CANAL ZONE TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Westbound-									
Balboa to Japan	Tanker	23/20.16	24/18.96	17/26.38	30/30.95	21/22.74	22/22.88	24/24.25	23/25.05
	Freighter	16/13.85	15/12.55	19/17.97	23/14.91	15/19.25	18/19.15	18/19.55	15/15.16
	Container	4/9.03	15/14.69	4/11.27	18/12.39	5/11.19	16/14.97	6/14.04	14/12.19
	Dry Bulk	67/24.41	72/20.50	49/23.31	77/22.76	58/20.88	70/19.91	68/22.22	66/15.54
Eastbound -									
Japan to Balboa	Tanker	28/19.77	33/21.04	21/25.49	45/26.18	28/21.41	38/21.09	35/17.33	32/17.10
	Freighter	32/15.05	39/14.82	26/15.15	48/15.38	28/15.83	36/15.48	31/14.41	35/14.30
	Container	5/15.74	22/14.72	4/21.55	24/15.97	4/17.61	22/13.13	5/14.55	20/15.86
	Dry Bulk	33/16.70	47/16.58	29/18.75	60/17.92	32/22.12	51/19.90	37/21.76	45/22.87

n = sample size

s = standard deviation

Sample Count:

Routed Vessels 1116

Unrouted Vessels 732

EAST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Eastbound-U.S. East Coast (USNH)*to Northern Europe	Tanker	3290/224	3240/219	3310/233	3275/228	3275/221	3235/218	3185/214	3170/213
	Freighter	3245/174	3225/171	3310/181	3245/176	3245/173	3220/170	3165/167	3150/166
	Container	3225/148	3180/145	3290/154	3225/150	3210/147	3185/145	3150/144	3140/143
	Dry Bulk	3285/231	3235/226	3315/244	3270/237	3280/231	3230/227	3195/223	3165/220
Westbound-Northern Europe to U.S. East Coast (USNH)*	Tanker	3360/240	3315/235	3450/263	3400/256	3340/240	3305/236	3245/222	3205/219
	Freighter	3325/185	3305/181	3425/198	3380/192	3320/186	3300/182	3195/172	3165/170
	Container	3315/156	3280/154	3375/166	3340/161	3300/157	3275/134	3170/145	3160/144
	Dry Bulk	3375/252	3330/245	3465/274	3420/266	3365/255	3320/249	3260/229	3210/226

*U.S. North of Hatteras

Sample Count:
Routed Vessels 1361
Unrouted Vessels 297

EAST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Eastbound - U.S. East Coast (USNH)* to Northern Europe	Tanker	11/17.92	46/11.43	9/13.33	62/11.39	12/16.06	45/10.71	16/10.42	42/9.45
	Freighter	12/15.26	48/11.21	10/15.04	58/12.81	10/10.46	49/9.15	14/12.28	43/10.28
	Container	3/6.81	30/9.67	4/6.60	31/9.99	3/5.13	30/10.39	3/5.69	28/10.56
	Dry Bulk	8/19.91	46/15.83	7/21.98	49/16.91	10/18.87	43/20.48	14/20.79	39/17.11
Westbound - Northern Europe to U.S. East Coast (USNH)*	Tanker	11/14.18	45/9.80	8/13.78	59/9.87	13/12.60	43/9.54	17/14.61	40/12.66
	Freighter	13/12.61	48/10.74	9/15.60	56/11.78	12/13.14	50/11.05	15/11.20	42/9.73
	Container	3/12.50	30/9.22	4/11.17	32/8.90	4/7.97	29/9.36	3/9.87	28/11.47
	Dry Bulk	7/17.80	44/13.71	8/16.90	50/16.04	11/16.96	40/13.64	13/18.08	36/15.11

* U.S. North of Hatteras

n = sample size

s = standard deviation

Sample Count:

Routed Vessels 1361

Unrouted Vessels 297

EAST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Eastbound-U.S. East Coast (USNH) to the Mediterranean	Tanker	3365/227	3355/225	3465/242	3410/235	3395/229	3345/225	3290/221	3280/218
	Freighter	3355/178	3315/174	3410/186	3355/181	3365/179	3310/174	3280/171	3260/169
	Container	3290/150	3270/148	3325/156	3295/152	3290/150	3265/148	3260/148	3245/147
	Dry Bulk	3360/235	3460/233	3460/253	3400/245	3380/236	3330/233	3285/228	3275/226
Westbound-Mediterranean to the U.S. East Coast (USNH)	Tanker	3490/249	3410/240	3590/272	3530/263	3485/251	3420/246	3330/228	3295/223
	Freighter	3415/190	3375/186	3495/201	3465/198	3425/191	3380/186	3310/177	3270/173
	Container	3305/155	3285/152	3465/169	3405/164	3395/160	3360/157	3275/150	3255/148
	Dry Bulk	3480/256	3405/247	3595/280	3520/270	3480/262	3435/253	3330/235	3290/230

Sample Count:

Routed Vessels 1123

Unrouted Vessels 220

EAST COAST UNITED STATES TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Eastbound – U.S. East Coast (USNH) to the Mediterranean	Tanker	8/19.91	42/15.62	6/16.13	48/13.05	7/13.35	43/15.79	10/17.80	32/13.95
	Freighter	5/14.71	33/10.20	4/13.57	35/10.61	6/13.06	35/11.13	8/14.70	28/10.82
	Container	3/10.02	20/9.81	3/5.69	20/10.94	3/6.03	19/10.04	4/10.90	19/12.01
	Dry Bulk	8/19.51	53/19.81	8/19.56	57/18.98	9/21.51	49/18.69	12/17.00	40/16.12
Westbound – Mediterranean to the U.S. East Coast (USNA)	Tanker	9/16.29	40/12.01	7/18.95	47/14.73	8/19.32	41/13.21	10/16.85	33/12.96
	Freighter	6/16.60	30/12.21	4/21.19	34/13.17	7/8.19	31/11.83	10/11.50	28/10.17
	Container	4/5.38	19/8.66	3/4.51	19/10.71	3/9.07	18/10.97	4/9.81	18/11.63
	Dry Bulk	9/21.29	50/18.71	8/19.66	54/17.32	10/18.91	47/19.07	14/20.86	41/16.47

n = sample size

s = standard deviation

Sample Count:

Routed Vessels 1123

Unrouted Vessels 220

GULF OF MEXICO TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Eastbound-U.S. Gulf to Northern Europe	Tanker	4655/312	4600/307	4735/319	4695/315	4705/314	4620/308	4400/291	4320/284
	Freighter	4590/242	4585/241	4705/249	4675/246	4600/243	4550/241	4325/227	4305/224
	Container	4555/207	4580/208	4640/213	4660/212	4595/209	4505/204	4290/194	4235/191
	Dry Bulk	4635/322	4590/317	4720/331	4715/327	4730/324	4635/320	4410/302	4310/293
Westbound-Northern Europe to U.S. Gulf	Tanker	5050/348	4990/344	4895/350	4900/345	4685/317	4670/316	4520/299	4470/298
	Freighter	5095/272	4905/267	4850/269	4875/268	4590/244	4580/243	4430/232	4415/232
	Container	4900/227	4870/227	4855/230	4880/230	4515/207	4500/206	4400/199	4350/198
	Dry Bulk	5120/363	4955/354	4910/364	4905/358	4600/322	4615/323	4505/311	4435/306

Sample Count:

Routed Vessels 1275

Unrouted Vessels 246

GULF OF MEXICO TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Eastbound –									
U.S. Gulf to Northern Europe	Tanker	9/25.52	45/18.32	7/18.88	58/15.23	9/21.77	48/15.97	13/17.09	38/17.57
	Freighter	6/14.56	38/9.36	4/17.21	48/11.78	7/15.71	38/10.11	9/12.29	34/12.61
	Container	4/6.75	22/9.96	3/14.11	23/8.71	4/5.38	21/8.99	5/8.07	19/7.39
	Dry Bulk	10/21.71	54/17.19	9/22.38	56/18.47	10/19.81	52/16.21	11/20.40	44/17.37
Westbound –									
Northern Europe to U.S. Gulf	Tanker	9/21.63	45/17.83	8/17.46	57/18.27	9/19.37	48/16.28	13/15.21	39/15.93
	Freighter	6/18.31	37/12.74	5/8.76	49/13.26	7/12.96	35/14.09	9/15.01	35/13.87
	Container	5/11.97	21/8.47	4/5.91	23/10.61	4/8.92	20/9.37	6/9.87	21/11.71
	Dry Bulk	10/21.99	53/18.61	8/23.86	58/20.04	9/19.61	54/19.28	14/17.44	42/18.01

n = sample size
s = standard deviation

Sample Count:
Routed Vessels 1275
Unrouted Vessels 246

GULF OF MEXICO TRADE ROUTES

Route	Vessel Type	FALL Unrouted (Dist/Time)	FALL Routed (Dist/Time)	WINTER Unrouted (Dist/Time)	WINTER Routed (Dist/Time)	SPRING Unrouted (Dist/Time)	SPRING Routed (Dist/Time)	SUMMER Unrouted (Dist/Time)	SUMMER Routed (Dist/Time)
Eastbound- U.S. Gulf to the Mediterranean	Tanker	4515/303	4520/303	4505/306	4495/304	4470/300	4465/299	4460/299	4455/297
	Freighter	4475/238	4460/236	4470/238	4455/237	4410/231	4415/231	4405/233	4395/231
	Container	4430/203	4405/200	4410/203	4415/202	4415/201	4405/199	4405/202	4380/193
	Dry Bulk	4560/319	4500/310	4500/317	4490/314	4520/316	4460/310	4470/309	4440/306
Westbound- Mediterranean to U.S. Gulf	Tanker	4520/307	4530/306	4525/308	4515/307	4485/304	4470/300	4500/298	4505/298
	Freighter	4480/242	4465/239	4475/240	4480/240	4435/237	4420/234	4425/232	4415/231
	Container	4435/204	4420/203	4420/202	4430/204	4440/204	4425/202	4400/199	4400/193
	Dry Bulk	4535/314	4495/309	4500/317	4505/317	4470/312	4465/310	4505/312	4480/307

Sample Count:

Routed Vessels 1402

Unrouted Vessels 277

GULF OF MEXICO TRADE ROUTES

Route	Vessel Type	FALL Unrouted n/s	FALL Routed n/s	WINTER Unrouted n/s	WINTER Routed n/s	SPRING Unrouted n/s	SPRING Routed n/s	SUMMER Unrouted n/s	SUMMER Routed n/s
Eastbound - U.S. Gulf to the Mediterranean	Tanker	12/22.18	47/19.08	8/26.12	62/21.33	10/20.84	52/20.61	16/18.96	40/19.31
	Freighter	6/15.01	43/12.91	5/20.61	53/14.07	9/14.32	44/10.81	12/14.11	37/14.0[illegible]
	Container	4/6.45	25/7.51	4/10.28	26/8.32	5/6.20	23/6.90	6/9.31	20/8.88
	Dry Bulk	11/24.01	56/19.33	8/25.11	61/19.67	13/22.48	55/18.79	17.19.99	46/20.1[illegible]
Westbound - Mediterranean to U.S. Gulf	Tanker	10/25.22	51/19.39	8/16.33	62/21.41	11/20.99	52/18.10	15/21.22	40/20.7[illegible]
	Freighter	6/11.61	48/13.98	4/20.22	53/15.21	7/18.35	47/14.76	10/16.22	39/15.01
	Container	6/8.23	24/9.31	4/12.95	27/10.01	5/9.76	22/8.98	6/11.63	21/9.76
	Dry Bulk	10/27.32	57/20.11	7/23.08	64/22.68	10/24.71	59/19.88	14/21.78	46/21.1[illegible]

n = sample size

s = standard deviation

Sample Count:

Routed Vessels 1402

Unrouted Vessels 277

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