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THE COST OF SHIPPING IRON ORE
ON THE GREAT LAKES

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THE COST OF SHIPPING IRON ORE ON THE GREAT LAKES

By

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ABSTRACT

THE COST OF SHIPPING IRON ORE
ON THE GREAT LAKES

By

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This research considers the problem of the cost of shipping iron ore on the Great Lakes and the oceans. Its purpose is to quantify actual costs in order to provide those involved with this industry an alternative to posted prices and to present a flexible, simple cost model applicable to a wide variety of cases. Results show that the Great Lakes bulk carrier fleet has changed dramatically in recent years as ship owners have relied increasingly on fewer but larger vessels to capture significant cost reducing economies of scale. The results also indicate large differences between listed prices and actual costs and that the cost model presented here is a useful policy tool.

DEDICATION

To the men of the Edmund Fitzgerald whose fate reminds us of the ultimate cost of shipping iron ore.

ACKNOWLEDGEMENTS

In the course of this research many people were consulted without whom it would have been impossible to produce this dissertation. I gratefully acknowledge the help of those members of various private businesses I consulted and who patiently critiqued the cost sheets and educated me in the shipping business. Since the information they provided was largely proprietary, their names are withheld.

I am also grateful to certain members of the Maritime Administration for providing me with certain cost information and other insights into shipping. I refer to Mr. Steve Caponitti of the Washington, D.C. office and to Mr. Bob St. Alban of the Cleveland office.

For their advice on various engineering and technical features of Great Lakes vessels, I wish to acknowledge members of the Department of Naval Architecture and Marine Engineering of the University of Michigan. These include Drs. Harry Benford, Michael Parsons and Bob Scher.

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Special thanks goes to my advisor Dr. Peter Kakela whose constant advice and guidance and numerous personal contacts with industry executives as well as his provision of other resources made this project possible. I hope the close working relationship continues long after the data here are outdated.

Finally, I acknowledge with gratitude the help of my wife, Clarissa, for proofing the work at various stages and to Sue Chatterley and Nora Beckett for the typing and numerous revisions of this manuscript.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES AND EXHIBITS

LIST OF SYMBOLS, ABBREVIATIONS, OR NOMENCLATURE

LT	=	Long tons (2,240 pounds)
RFR	=	Minimum required freight rate
BP	=	Between perpendiculars
DFC	=	Daily fuel consumption
Voyage Days	=	Total trip days including steaming and port time
Loading Rate	=	Amount of long tons loaded per hour
Unloading Rate	=	Amount of long tons unloaded per hour
Season	=	Number of shipping days within a year
Ton-miles/gallon	=	The number of cargo tons carried one mile on one gallon of fuel
DWT	=	Deadweight tonnage (in long tons)
CRF	=	Capital recovery factor
Tonnes	=	Metric tons
LTP	=	Long tons of pellets
VRA	=	Voluntary restriction arrangements

CHAPTER I

INTRODUCTION

The increasing interdependence of the world economy has become an especially important issue with the worldwide slowdown in economic growth, the increasing economic nationalism of many countries, dislocations in industrial production, and the mounting debt of many Third World countries. No national economy can be insulated from these global economic forces.

One natural resource which illustrates these problems is iron ore which has grown to be a worldwide commodity in the last thirty years. Yet with the loss of price competitiveness in the late 1970's and in the mid-eighties, iron ore production in the United States dropped. In 1979 the U.S. produced 77 million long tons of pelletized iron ore but by 1986 this was reduced to around 38 million tons or about 49% of the 1979 level.[1] As one report stated: "The 1986 iron ore shipments represent a 12 percent decline from 1985. Turn the calendar back to the boom year of 1979 and the ore trade has plunged more than 50 percent".[2] The author concludes that "foreign steel is the cause for

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1 Marcus, Peter F., Karlis M. Kirsis and Peter J. Kakela; <u>World Steel Dynamics: The Threatened North American Iron Ore Industry</u> (Core Report Z); PaineWebber; April, 1987; p. 1-3.

2 Ryan, George J. "The Impact of Foreign Steel" in <u>Seaway Review</u>, Vol. 16, No. 1 (January-March, 1987): 53.

the five year slump in iron ore shipments." He also blames finished goods imported into the U.S. and calls for more "effective controls" to be placed on foreign steel. These controls would, presumably, take the effect of mandatory import restrictions or tariffs.

Kirsis and Kakela likewise state that between 1979 and 1986 iron ore production in the U.S. has gone down by 50%. Despite closings and reductions of production, severe overcapacity continues to plague the industry. They estimate this overcapacity to be 16.2 million long tons in 1986. Canada faces similar difficulties. Its excess capacity for 1986 was 10.7 million long tons. And yet at the same time foreign producers have "enormous excess capacity." This has contributed to the decline and break-up of common pricing and prices have fallen from $55.62/LTP in 1985 to a range of posted prices in 1987 which go as low as $34.50/LTP delivered to Chicago. Also, the U.S. spot market, born in 1982, has seen prices fall from $32 to $33/LTP in 1982 to $26 to $27/LTP in 1987 (delivered to Chicago).[3]

The fate of the iron ore industry is, of course, related to that of the steel industry. Many steel plants have had to close or file bankruptcy and in some cases, reorganize and restructure as a new, more competitive firm with reduced costs (including making significant wage cuts). It also has reduced costs by investing in continuous casting technology and so has lowered "production costs by 20 percent." This process has risen surprisingly quickly going from 44.4% in 1985 to 70% of projected 1987 production. Furthermore,

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[3] Kirsis, Karlis M. and Peter J. Kakela; <u>World Steel Dynamics: The U.S. Spot Iron Ore Market</u>; Paine Webber; September 8-9, 1987; pp. 2,3.

> Every major steelmaker has built a new electrogalvanizing line, each of them removed from basic steel in order to obtain more favorable labor costs and work rules.[4]

The steel industry has also sought new markets, improved the quality of its product and tried to develop new uses for steel. Precisely because of such changes the industry's situation appears to be improving.[5]

Foreign steel firms, though, also face serious problems. The German government will no longer subsidize its steel industry and has recently criticized aid given by the EEC from the years 1980-1985 and amounting to about $38 to $40 billion. Some 15,000 workers in steel were expected to be laid off by the end 1987. One EEC commission has ordered two French steel groups to pay back their government the aid its subsidiaries received from 1983-1985 amounting to $511 million.[6]

The Brazilian government, however, has given its steel industry $2 billion to help alleviate its enormous debt problem. But Brazilian steel prices have not risen. Instead, "A government freeze on all prices has kept Brazilian steel prices 30 to 40 percent below production costs."[7]

The Brazilian list price per long ton of pellets is about $23.87 (f.o.b. at Tubarão). When the transportation cost of delivery to

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4 Thompson, Renold D.; "Surviving in the Global Market Place" in Seaway Review, Vol 16, No. 2 (April-June, 1987): 35.

5 Ibid.

6 Ibid.

7 Ibid.

Chicago is added on of $13.75/LTP, the Lower Lakes price is $37.62/LTP.[8]

The viability of the U.S. steel and iron ore industries can be understood in part by examining the discrepancy between listed prices and actual costs. In explaining the costing method, the PaineWebber study states:

> The steel companies' equity ownership of iron ore mines was a key factor leading to the traditional 'cost-plus' pricing structure. In addition, when the steel companies purchased ore from the mine management firms...they traditionally paid the 'posted' Lower Lakes list price....The Lower Lakes posted or list price in the past often ran well above costs."[9]

The study estimates that for 1986 the most common posted price of $46.40/LTP delivered to Chicago was 21% above the pretax costs "at the actual operating rate for the three best U.S. plants..."[10]

The problems of the iron ore and steel industries are closely related not only because of the natural and technological links but also because of the high level of vertical integration between these industries. More than 80% of the iron ore produced in the U.S. is controlled by equity ownership of American steel companies.[11] Another natural link in the industry's vertical integration is the

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8 Ibid., p. 12.

9 Kirsis and Kakela, op. cit., p. 7.

10 Ibid.

11 Ibid., p. 2.

transportation of northern Minnesota's and Michigan's iron ore to the Lower Lakes ports and the nearby steel mills. This is a matter of shipping on the Great Lakes and many steel companies own their own fleets or have long term leases on fleets. The cost of shipping then plays a part in understanding the overall cost problems and competitive viability of the iron ore and steel industries. That understanding is also enhanced by examining the historical changes in the fleet to see how shippers have tried to accommodate changing economic conditions and in recent years that means lowering cost.

Some politicians have expressed an interest in the problems of Great Lakes shipping. For example, Congressman Walter B. Jones (D-NC) has stated:

> I believe that this deterioration of the U.S.-flag presence on the Great Lakes provides an example of what may happen to the rest of our maritime trades. Perhaps by an intensive study of Great Lakes trade, we can determine what went wrong there, how we might correct it, and how we might avoid a similar decline elsewhere.[12]

Rep. Jones also takes a protectionist view of the matter. Yet protectionist policies would clearly affect several nations including Canada, Japan, Korea, West Germany, and Brazil. Brazil is especially sensitive to such protectionist measures since it already faces a worsening external payments position. In 1982, it received a $304 million loan from the World Bank which it is hoped will help its

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[12] Anonymous; "Addressing Major Great Lakes/Seaway Issues" in Seaway Review, Vol. 14, No. 3 (June-August, 1985): 47.

economy and its external payments problem.[13] Brazil also has attempted to market its iron ore to the Great Lakes region and at least one shipper has opened up monthly cargo service for Brazilian and Great Lakes ports.[14]

Yet while Brazil was at one time thought to be a very real threat to the U.S. iron ore industry, its actual impact has been small, if not negligible.[15] Still, with its large fleet and iron reserves, it continues to be a potential threat to the American iron ore industry. In discussing the problem of iron ore imports as a "major threat" to the U.S. steel industry, Robert McInnes specifically cites the development of Brazil's Carajas region, supported in part by the World Bank, as a major economic concern.[16]

So far as the transportation link goes in the iron ore/steel industries, concern continues on the limitations imposed on shipping by the size of the locks. Great Lakes Task Force Chairman Mel Pelfrey is concerned, among other things, about the construction of an additional lock to "relieve the congestion and costly delays through the Poe lock." The Poe lock is a vital link in Great Lakes shipping for iron ore and fossil fuels transported to steel mills and utilities on the

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[13] Anonymous: "The Iron Range, Brazil and the World Bank" in the Minneapolis Star and Tribune, August 23, 1982.

[14] Anonymous: "Saguenay Opens Lakes Service to Brazil" in Seaway Review, Vol. 14, No. 4 (September-November, 1985): 16.

[15] Kirsis, Karlis M. and Peter J. Kakela: World Steel Dynamics: The Threatened North American Iron Ore Industry; PaineWebber: April 26-28, 1987; p. 17.

[16] McInnes, Robert: "Status and Future of Lake Superior Iron Ore Industry" in Skillings Mining Review, February 25, 1984: p. 8.

lower Great Lakes. Pelfrey refers to a Corp of Engineers study supporting the construction of such an additional lock.[17] That study recommends construction of a lock 1294-feet in length, 115-feet in breadth and with an 32-foot depth: "This size is intended to facilitate use by the largest existing vessels in the U.S. Great Lakes fleet."[18] More recently the federal government (in PL-99-662, Sec. 1149) has authorized the construction of such a lock.

Within this context the role of shipping costs clearly emerges as crucial to any country's iron ore industry. For example, Dr. Robert Crandall, an authority on steel industry economics at the Brookings Institution, indicates that one important reason for the decline of the U.S. position in the world steel market is due to the development of larger, lower-cost bulk ocean liners for shipping iron ore. [19] Crandall states that the decline in the concentration of iron ore shipments since the 1950's and the marginal decline in metallurgical coal output "combined with lower [ocean] shipping costs, have allowed virtually any country with good port facilities to obtain its basic raw materials as cheaply as the U.S. steel industry."[20]

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[17] Anonymous: "Pelfrey Articulates the Issues" in Seaway Review, Vol. 14, No. 3 (June-August, 1985): 49.

[18] Beurket, Jr., Raymond T.: "Lean Years Ahead for Commercial Navigation Projects" in Seaway Review, Vol. 14, No. 3 (June-August, 1985): 81.

[19] Crandall, Robert W.: The U.S. Steel Industry in Recurrent Crisis: Policy Options in a Competitive World (Washington, D.C.: The Brookings Institution, 1981), p. 20.

[20] Ibid., p. 21.

Shipping, then, plays an important role in the iron ore and steel industries and an understanding of it within such a context is the purpose of this research. The specific objectives and methods of the research are detailed in the next chapter.

CHAPTER II

OBJECTIVES AND METHODS

Objectives

In order to understand the complete picture of the cost of producing iron ore and steel, and thereby the health or viability of these industries, the shipping cost components must be understood. This broad research goal resolves itself into three specific objectives. They are:

1. To examine how selected characteristics of the Great Lakes fleet have changed over time;

2. To determine present total and component costs for Great Lakes shipping; and

3. To determine present total and component costs for ocean shipping and compare these with Great Lakes shipping.

To realize these objectives, it is necessary to establish a practical cost model in the form of a cost sheet that is simple, flexible and reasonably accurate and which will be of use to relevant firms involved in the shipping of iron ore.

There are a variety of reasons for undertaking cost estimate studies. As Heaver writes:

> Owners want to make their decisions based on good estimates of the costs of owning and operating particular types of vessels. For shippers, the development of specialized vessels has made long-term charters of specially designed ships important. Shippers have found that a good knowledge of owners' costs is desirable when assessing the attractiveness of long-term arrangements.[21]

Elsewhere Heaver writes that "a good knowledge of the components of ship costs is important for the owners and charterers of ships because of the influences of costs on charter rates."[22] Such knowledge is vital if he is successfully "to negotiate satisfactory escalation conditions."[23] Port authorities need to know the benefits (cost-savings) that are derived by shipowners from the use of different facilities. Heaver likewise believes cost studies are helpful in national policy decisions. Such decisions may involve questions of the balance of payment effects of ship registry, studies of national flag

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21 Heaver, Trevor D.: "The Treatment of Ships' Operating Costs" in Maritime Policy and Management, Vol. 12, No. 1 (1985): 35.

22 Ibid., p. 41.

23 Ibid.

shipping, or the effect of manning arrangements on crew and other operating costs.[24]

Showing a similar concern for the need of cost estimates in shipping Benford cites four broad justifications for such research. These include the need of national policy makers to make decisions on such projects as winter navigation, dredging, lock construction and port planning; or for issues of subsidies and other kinds of support. Cost estimates help fleet managers make decisions between alternative kinds of investments, in drawing up budgets or predicting charter and insurance rates. Naval architects need such studies for design purposes and shipyard managers require cost studies to bid on new constructions.[25]

The reason for being concerned about costs in this study is, broadly, two-fold. First it is important to an understanding of the shipping and iron ore industries, in comprehending their competitive posture, or their viability. Secondly, it is important to shippers to understand how close the price they pay is to actual costs. The most common listing is that of posted prices found in relevant trade journals (e.g., Skillings Mining Review). It would be useful for such shippers to have a model of shipping costs that is both flexible and simple and yields reasonably reliable estimates of costs.

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[24] Ibid., p. 44.

[25] Benford, Harry; "Ships Capital Costs: The Approaches of Economists, Naval Architects and Business Managers" in Maritime Policy and Management, Vol. 12, No. 1 (1985): 10.

Methods

The concepts used in the research are taken from both economics and energy analysis. The concept of "economies of scale" is essential to the study. This refers to the fact that differences in scale of an operation affect the returns an operator receives. The concrete physical expression of the economies of scale is reflected in ship size. Generally, the larger the ship the greater the economies achieved.[26] It is common to use the required freight rate (RFR) as a measure of total cost which among other things reflects vessel size as well as fuel, crew, interest, etc. plus a percentage return on those costs. The RFR is the minimum rate a shipper must charge to stay in business over the long run. Thus, as vessel size increases, one would expect, ceteris paribus, the RFR to decrease.

This concept is closely related to another economic concept of "efficiency" where the operator seeks to optimize the use of his resources. But in this case "efficiency" has more the physical and the engineering meaning associated with energy analysis and "ton-miles/gallon"; i.e., the fuel energy it takes to move one long ton of iron ore one mile. The less energy to make such a move the more efficient the transportation is said to be.

The point of view assumed throughout this study is that of the shipping operator which in almost every case is a steel company since steel companies usually own and operate their own fleets. The operator

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[26] Nilsson, Dan; "World Merchant Fleets Development" in <u>Skillings Mining Review</u>, December 6, 1980; p. 12.

is assumed to be interested in shipping as much as possible for the lowest cost.

In other words the proposed research uses orthodox concepts. It assumes their validity. No attempt is suggested for testing these standard concepts or introducing and testing new ones. Rather it is within this orthodox conceptual framework that the extent and quality of the assumed relationships is determined and the appropriate variable quantified. The research, then, is one of fact-finding with the use of orthodox concepts.

The cost sheet or model is written on a common spreadsheet computer program (Lotus 1,2,3).

Data Acquisition

The data for the cost model come from two main sources. First, in order to track historic and expected future changes in ship size, average fleet characteristics have been calculated. These characteristics are reflected as summary statistics for the ship's length (between perpendiculars), beam, depth and carrying capacity (at mid-summer draught). These summary characteristics have been calculated separately at five-year intervals for all bulk carriers and self-unloaders on the Great Lakes/St. Lawrence Seaway system from 1960-1985. Whenever aggregation of information occurs, some information is lost of the particular or singular. Each ship and each voyage is different in many ways. With variations in crew, cargo, weather and route costs will vary somewhat. There are, however, limits to these variations whose significance fades in the broad picture and over the long run so that reasonably accurate typical costs can be obtained.

The second source of data comes from direct contact with various industry officials, industrial suppliers and published values for such data as fuel costs, tax rates, amortization, ship life expectancy, initial cost of vessel, type of propulsion and so on.

Although no historical study is done, the data for ocean shipping are obtained in a similar manner, including the use of trade journals, other published values and interviews with shipping executives and consultants.

The Concept of Cost

What is a cost? For the economist the mainstream definition is based on the concept of opportunities that must be foregone or benefits tnat are lost in order to undertake a project or to acquire something else. It is normally defined in terms of the next best alternative whose real value must be sacrificed to undertake the project.

Another commonly employed concept of cost is that of the accountant whose only concern is with those legally binding inputs and outputs of the firm. What bills must be legally paid? What legally binding incomes are there? Do they balance? Opportunities that are foregone do not formally play a part here.

It is in this latter meaning that the present research employs the concept of cost, eschewing the more esoteric definitions of cost of the economist. Costs of the Seaway construction are not considered; if subsidies for ship construction are involved, as they are for the Canadians, these too, are not tracked through as far as tax incidence. Neither is environmental cost considered. This is not the cost of a firm's entire fleet nor of any interactive advantages derived from owning a variety of ships. It is rather merely the cost of a single ship pursuing a single route under favourable real-world conditions. The cost of the ship modelled here is theoretical, however, in the sense that some cost elements are averages which may not represent any actual vessel. It is not theoretical or ideal in the sense that the costing is a mere abstraction intended to satisfy some a priori theory or the outworking of assuming the validity of that theory. Rather it is practical and realistic in that the cost sheets were submitted to intense scrutiny from people who are in the business so that both the structure and the particular values are real-world ones. Even here the businessmen contacted did not speak with one voice and while they did not differ radically on technical or costing points, some judgmental decision-making on the part of the researcher unavoidably had to occur. If better information is available to a user for a particular costing project, he need only insert his values into the cost sheet and recalculate. Thus the boundaries of the meaning of cost are drawn fairly narrow but not too narrow to be meaningful in the real world of iron-ore shipping.

Similarly, the application of the cost sheet to certain policy questions must likewise be understood in the light of these restrictions.

CHAPTER III

LITERATURE REVIEW

A review of current literature reveals that the major issues surrounding Great Lakes development and transportation is not only of interest but is also highly controversial. While no study exists which purports to research the same aspects as outlined here, a number of studies and reports related to these aspects exist which underscore the need for such a study and which shows the complimentarity of this proposed research with these existing studies.

A recent study of grain exports by Binkley and Barnett, for example, deals with the Great Lakes and seacoast ports and necessarily touches upon questions of major interest in this proposal. For example, the authors found that a key to the competitive posture of the Great Lakes ports is the cost of shipping which in turn is significantly affected by ship size. The authors note that ship size in turn is limited by the existing system of Seaway locks which do not allow efficient use of existing large bulk carriers. The locks also cause bottlenecks, especially at the Welland Canal connecting Lake Ontario with Lake Erie. This again increases ship operating costs.[27]

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[27] Binkley, James K., and Douglas A. Barnett; The Great Lakes and Seacoast Ports: A Case Study of Competition in Grain Exporting, Station Bulletin No. 425, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana; September, 1983; p. 7.

The authors also found that the seasonality of the Great Lakes shipping indirectly raises the shipping costs, at least in the long run. Handling and loading systems are necessarily idle during the off-season and this affects the profitability of port and other investments that would lower shipping costs. Those ports not affected by such seasonality would be comparatively more attractive to invest in.

Overall the authors conclude that the volume of exports handled by Great Lakes ports is "particularly sensitive to changes in relative transport costs" and that "the elasticity of Lake shipments with respect to transport cost changes is likely to be large." They later add that the Great Lakes system in export grain "is unstable in the sense that it is especially responsive to transport costs."[28]

Howard A. Watters, in a paper presented to the National Coal Association also found that the Seaway lock size significantly constrains coal loading ports. He notes that U.S.-flag laker involvement in Seaway trade is minimal "because of a lack of maximum Seaway-size vessels" which is one reason U.S. shippers experience "higher freight rates." He also recognizes that: "Economy of scale is significant in low value bulk commodity trades" (e.g., coal and iron ore). Improvements can be made where coal can be combined with iron ore "for carriage in large, efficient ships."[29]

In yet another report on shipping Dan Nilsson observes the historical trend in sea trade has seen an increase in both size and

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[28] Ibid., pp. 17, 43.

[29] Watters, Howard A.: "Great Lakes Coal Transportation" in Skillings Mining Review, October 30, 1982; p. 8.

number of ships. One of the reasons for increasing size has been the increasing export of iron ore from "remote countries like Brazil" to markets in the eastern U.S. and elsewhere. In this report, Nilsson found:

> Larger vessel size normally means that the cost per ton transported will decrease. The reason is of course that the extra expense, incurred by increased size, is small relative to the resulting extra cargo capacity and that the size of the crew is rather independent of the vessel size.[30]

He specifically cites larger vessel size as having a substantial effect on transportation costs of iron ore.[31]

In another study of coal transfer facilities in the lower Delaware Bay, it was found that the cost of bulk shipments was significantly reduced by the increased size of ships. Yet this cost advantage was limited by the present depth of U.S. ports:

> Relatively limited depth waterways at east and gulf coast ports, however, preclude loading to capacity the large bulk carriers that are required to reduce the total cost of export coal to receivers.[32]

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30 Nilsson, op. cit., p. 12.

31 Ibid., p. 13.

32 Anonymous; "N.B.C.'s Floating Coal Transfer Facility in Lower Delaware Bay" in Skillings Mining Review, Vol. 70, No. 42, October 17, 1981; p. 14.

The report further indicates that "freight rates" from the U.S. east coast to Europe and the Far East are substantially affected by the size of ships (notably, differences in draught).[33]

The recent study by Booz, Allen and Hamilton, commissioned by John L. Emery of the U.S. St. Lawrence Seaway Development Corporation, came to several relevant conclusions. Among them the importance of vessel size for the Great Lakes was noted:

> The most important factor that differentiates Great Lakes and tidewater ports is the economies of scale (size of ships) associated with vessels serving the Great Lakes/Seaway system vs. tidewater ports.[34]

The study also found that the Seaway route is at a disadvantage unless it can find an "'alternative means of service during the period when the shipping season on the St. Lawrence Seaway is closed.'"[35]

Finally, Dr. John Hazard, former Assistant Secretary of Transportation for International Affairs in the Nixon Administration and presently situated at Michigan State University, argued recently at a management conference in Lansing for both season extension and lock expansion. Dr. Hazard claims that without these initiatives serious traffic problems will develop at the critical Welland Canal before 1995 and prospectively at the St. Lawrence Seaway sections by the year 2000.

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33 Ibid.

34 Anonymous; "An Appraisal of Seaway Cargo Potentials" in Seaway Review, Vol. 14, No. 3 (June-August, 1985): 27.

35 Ibid.

Such traffic problems will mean loss of regional business and income as industrial customers relocate.[36]

Dr. Hazard implicitly recognizes the importance of ship size to transport costs when he specifies that lock expansion or duplication should be 1200-feet x 110-feet x 30-feet, thus allowing for the largest lake vessels to pass through the entire system.[37]

He further argues that season extension will bring "'considerable economies of ship utilization.'" The benefits of season extension exceed costs, Hazard claimed, within a range from 2.3 to 9.6 times. Nevertheless, Dr. Hazard concludes with a plea to continue studying the navigation season question.[38]

The above literature reveals that problems exist for Great Lakes shipping in two main areas: (1) economies of scale with regard to both the season extension and lock expansion and (2) foreign imports, notably Brazil, the largest producer of iron ore.

There are also no explicit comparisons in the literature of Great Lakes and ocean shipping costs, especially with respect to iron ore (a major regional and international commodity).

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36 Anonymous; "Expanding Traffic: Hazard Speaks Out on Regional Development" in Seaway Review, Vol. 14, No. 3 (June-August, 1985): 147.

37 Ibid., p. 148.

38 Ibid., pp. 147, 148.

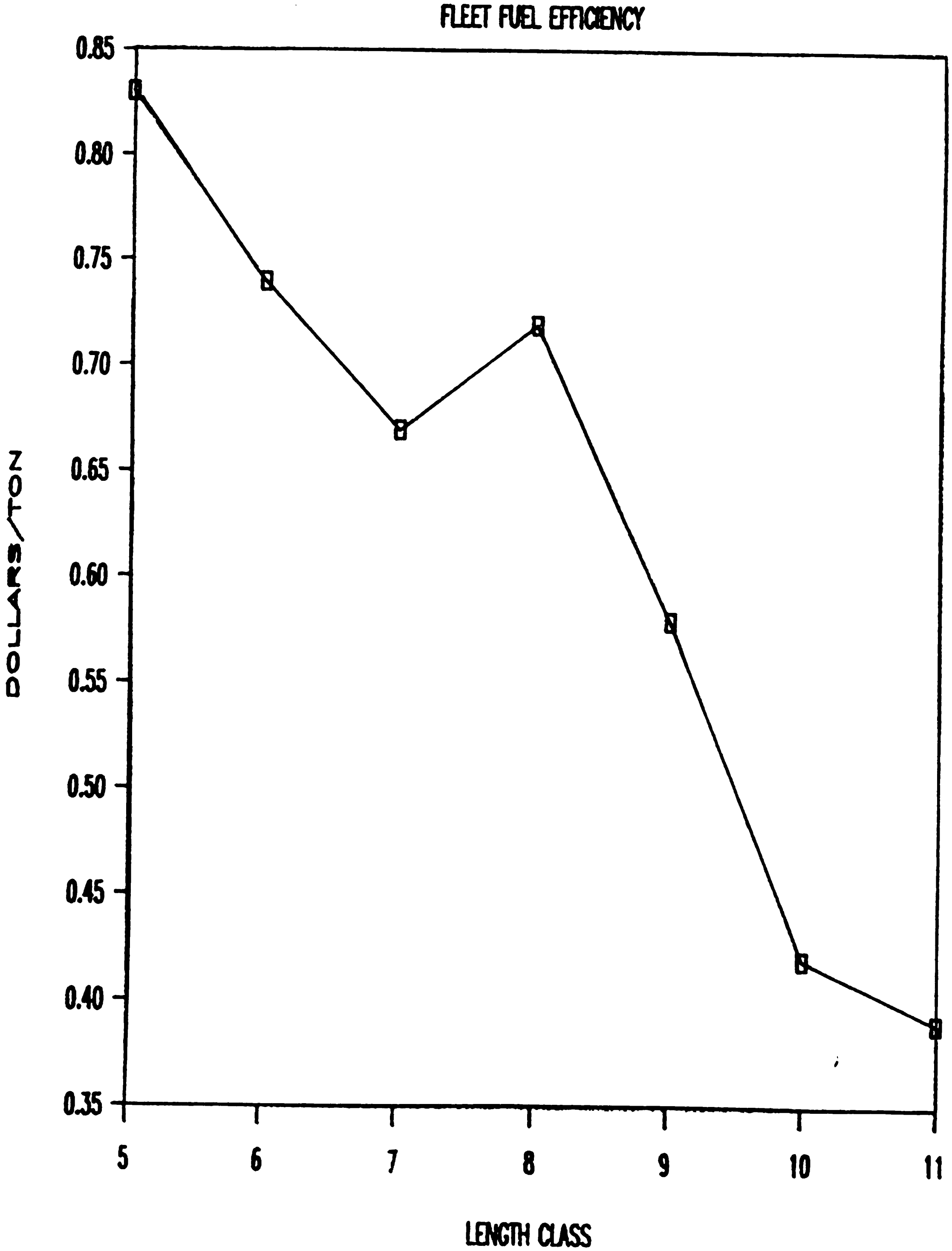
CHAPTER IV

HISTORICAL CHANGE

The Great Lakes shipping industry has changed over the years in many ways, especially with respect to basic fleet characteristics. These features include the size and the carrying capacity of Great Lakes vessels. The general trend has been toward fewer but larger ships. In this chapter these changes are documented by inspecting the changes in size and number from 1960 to 1985 in five year intervals, or approximately from the opening of the Seaway system to the present. The discussion is based on the use of vessel classes according to vessel length, similar to that of the Corps of Engineers.

The transformation of the fleet to ships that are larger in size but fewer in number is an effort to achieve certain cost reducing economies of scale. Figure I illustrates the greater fuel efficiency of the modern, larger vessels. For example, vessel class V, about 500 to 650 feet in length, costs $.83/long ton per trip for fuel while a Seaway sized or class VII vessel (c. 700-730 ft.) costs about $.67/long ton for fuel. The larger class X ship expends only $.42/long ton for

Figure I


FLEET FUEL EFFICIENCY
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
DOLLARS/TON
5
6
7
8
9
10
11
LENGTH CLASS

fuel.[39] In other words, fuel cost/ton declines with increases in the vessel's carrying capacity.

Table I and II and Figure II document the net changes in Great Lakes fleet numbers over the study period from 1960 to 1985. Figure II is a graph illustrating the information from Tables I and II (the negatively sloped striping indicates the number of vessels lost from the previous study year.) During that time the fleet size was reduced by 365 vessels. The most drastic reductions occurred between 1960 and 1965 and totaled 181 ships for that time. Of that number 139 alone were from class I (less than 400 ft.) or 77% of the net change of 181. The effect these changes have on cumulative tonnage is indicated in Figures III and IV.

Class II (400-500 ft.) lost 52 ships during that same period while class III (500-549 ft.) lost 20 vessels. Class IV (550-600 ft.) had no change; class V (600-650 ft.) lost two ships; vessel class VI (650-700 ft.) gained six vessels and the most dramatic gain occurred in vessel class VII (700-731 ft.) which gained 26 ships. The corresponding changes on the fleet cumulative tonnage is graphed in Figure IV.

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[39] The graph is based on data found in the Lake Erie Regulation Study Report to the International Joint Commission; Appendix D: Commercial Navigation (July, 1981) pp. 35, 39 from the International Lake Erie Regulation Study Board. It assumes a one-way trip distance of 785 miles. The speeds used to derive the graph are taken from the study and vary somewhat among the different classes. The higher cost for vessel class VIII is due to its smaller average tonnage despite its larger length classification, a result that is still consistent with the argument here. The dollar values are for 1979.

Table I

NUMBER OF SHIPS BY CLASS

LENGTH CLASS		1960	1965	1970	1975	1980	1985
0							
400	I	223	84	57	37	30	24
500	II	99	47	19	5	5	5
550	III	97	77	51	30	12	6
600	IV	95	95	89	75	58	22
650	V	53	51	51	48	48	46
700	VI	18	24	26	28	29	27
731	VII	2	28	46	48	58	66
850	VIII	0	0	0	8	14	13
950	IX	0	0	0	0	0	0
1001	X	0	0	0	2	9	13
	TOTAL	587	406	339	281	263	222

Table II

DIFFERENCES IN FLEET SIZE

YEAR	# OF SHIPS	NET CHANGE	%CHANGE	RATIO
1960	587	0	0	1.00
1965	406	181	-0.31	0.69
1970	339	67	-0.17	0.58
1975	281	58	-0.17	0.48
1980	263	18	-0.06	0.45
1985	222	41	-0.16	0.38

Figure II

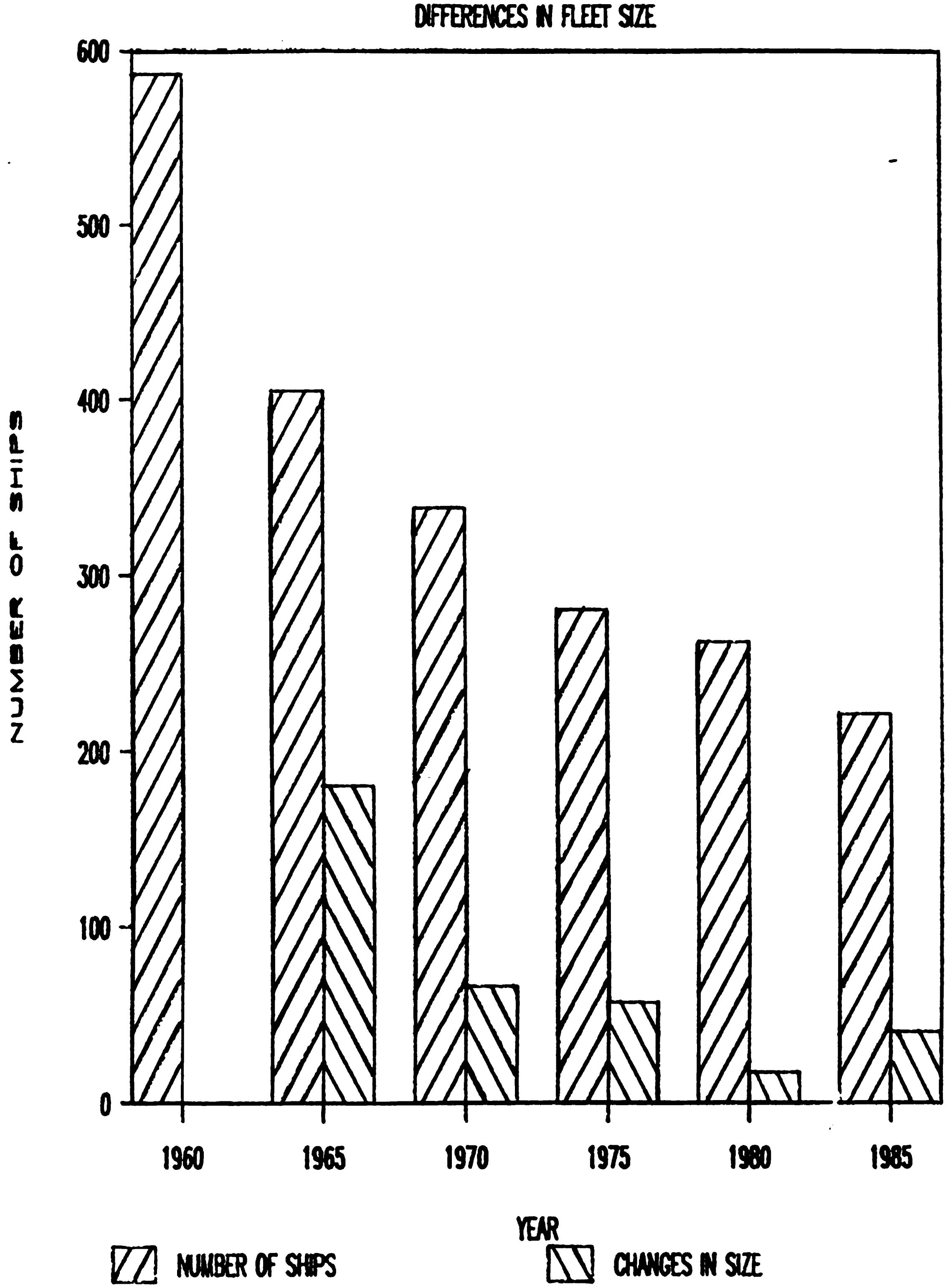

DIFFERENCES IN FLEET SIZE
600
500
400
300
200
100
0
NUMBER OF SHIPS
1960
1965
1970
1975
1980
1985
YEAR
NUMBER OF SHIPS
CHANGES IN SIZE

Figure III

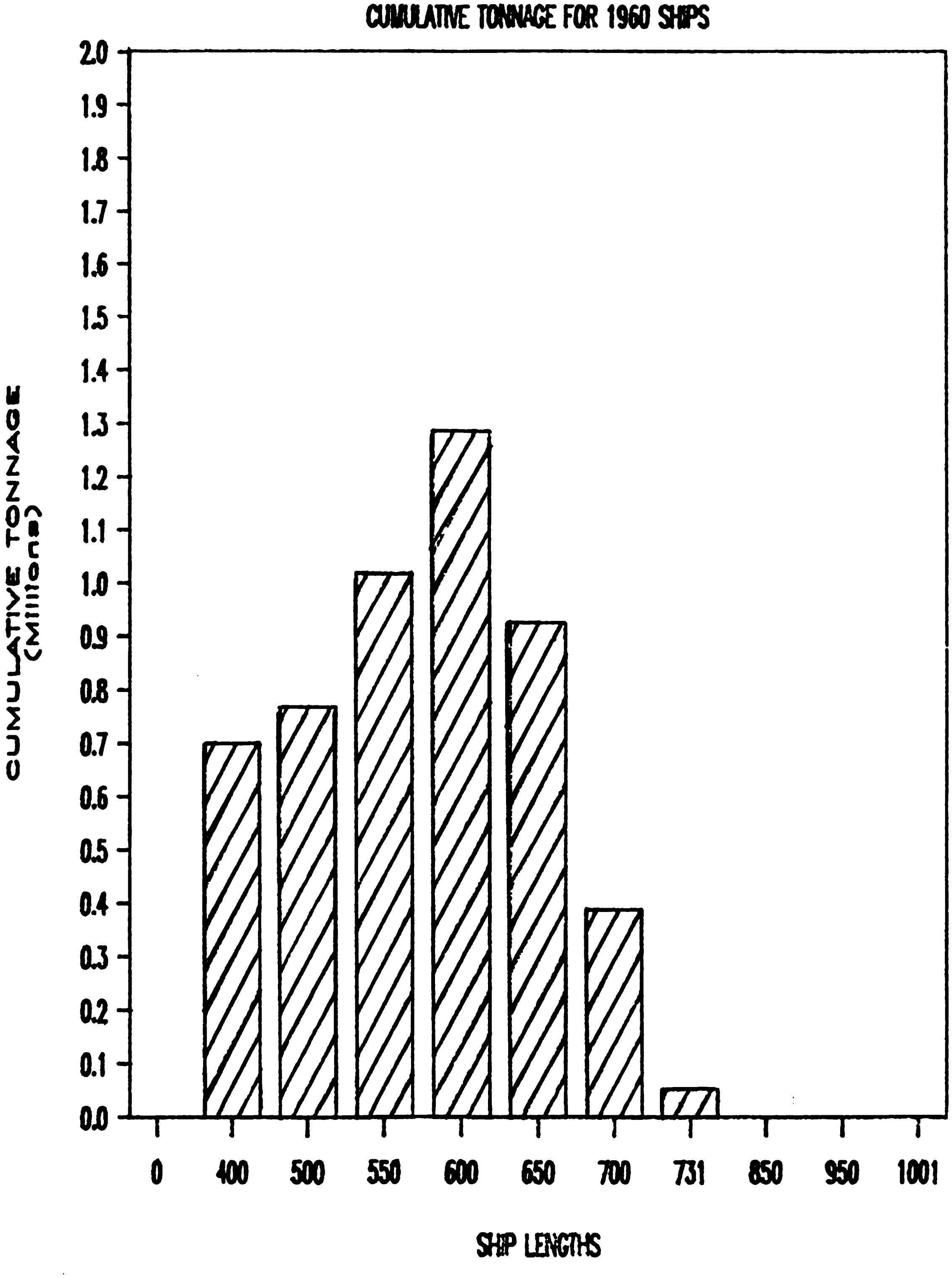
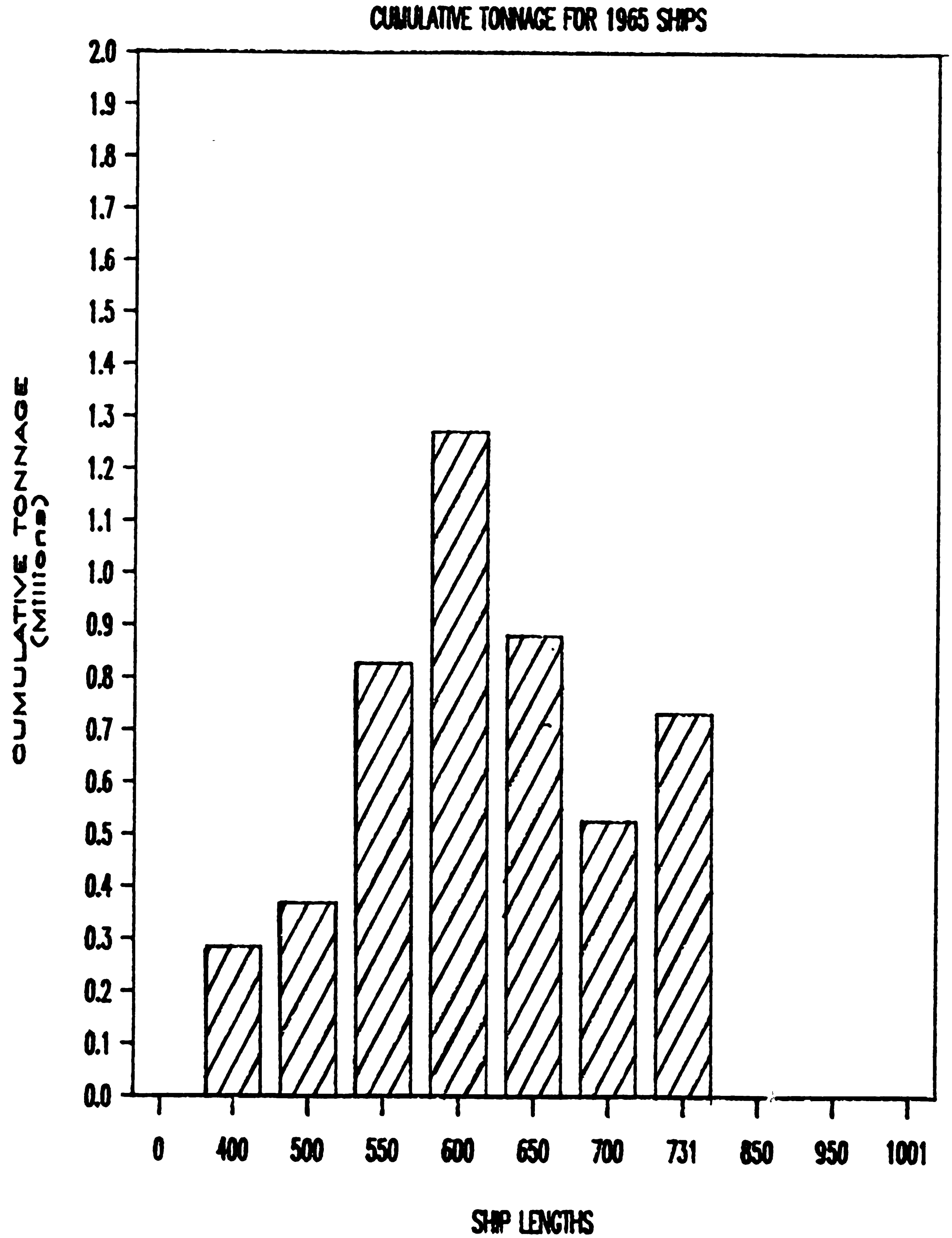

CUMULATIVE TONNAGE FOR 1960 SHIPS
CUMULATIVE TONNAGE (Millions)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
400
500
550
600
650
700
731
850
950
1001
SHIP LENGTHS

Figure IV



CUMULATIVE TONNAGE FOR 1965 SHIPS
CUMULATIVE TONNAGE (Millions)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
400
500
550
600
650
700
731
850
950
1001
SHIP LENGTHS

In the following period from 1965-1970, reductions also occurred in the smaller vessel classes (I-IV). Class V (600-650 ft.) remained unchanged. Class VI (650-700 ft.) gained somewhat but again class VII (700-731 ft.) had the most significant gains growing from 28 to 46 ships. There were no gains in the higher classes. Figure V illustrates these changes with respect to cumulative tonnage for 1970.

There is a continued reduction in 1970-1975 in the smaller classes, especially in class II (400-500 ft.) going from 19 to 5 ships. In the larger class V (600-650 ft.) we have a slight reduction from 51 to 48 ships. Additions were made to classes VI (650-700 ft.) and VII (700-731 ft.) again but it is class VIII (731-850 ft.) that stands out here: it gained eight "new" ships. Class X likewise is noteworthy since it now has two new ships, the thousand footers. Note the distribution of tonnage in Figure VI.

From 1975-1980 further reductions still occurred, though class II ships held steady at 5 as did class V vessels at 48. The remaining larger vessel classes (with the exception of class IX) continued to increase. Especially noteworthy is class VIII which grew from 8 to 14 ships and class X which increased from 2 to 9. Compare this with the cumulative tonnage graph of Figure VII.

Finally, in the interval 1980-1985, there were reductions in all the smaller classes, except class II (400-500 ft.) which continued to hold at 5 ships. Class III (500-550 ft.) was cut in half going from 12 to 6. Class IV (550-600 ft.) vessel size also dropped dramatically going from 58 to 22 ships; and so did class VI (650-700 ft.) falling from 29 ships down to a level of 27. However, class VII vessels

Figure V

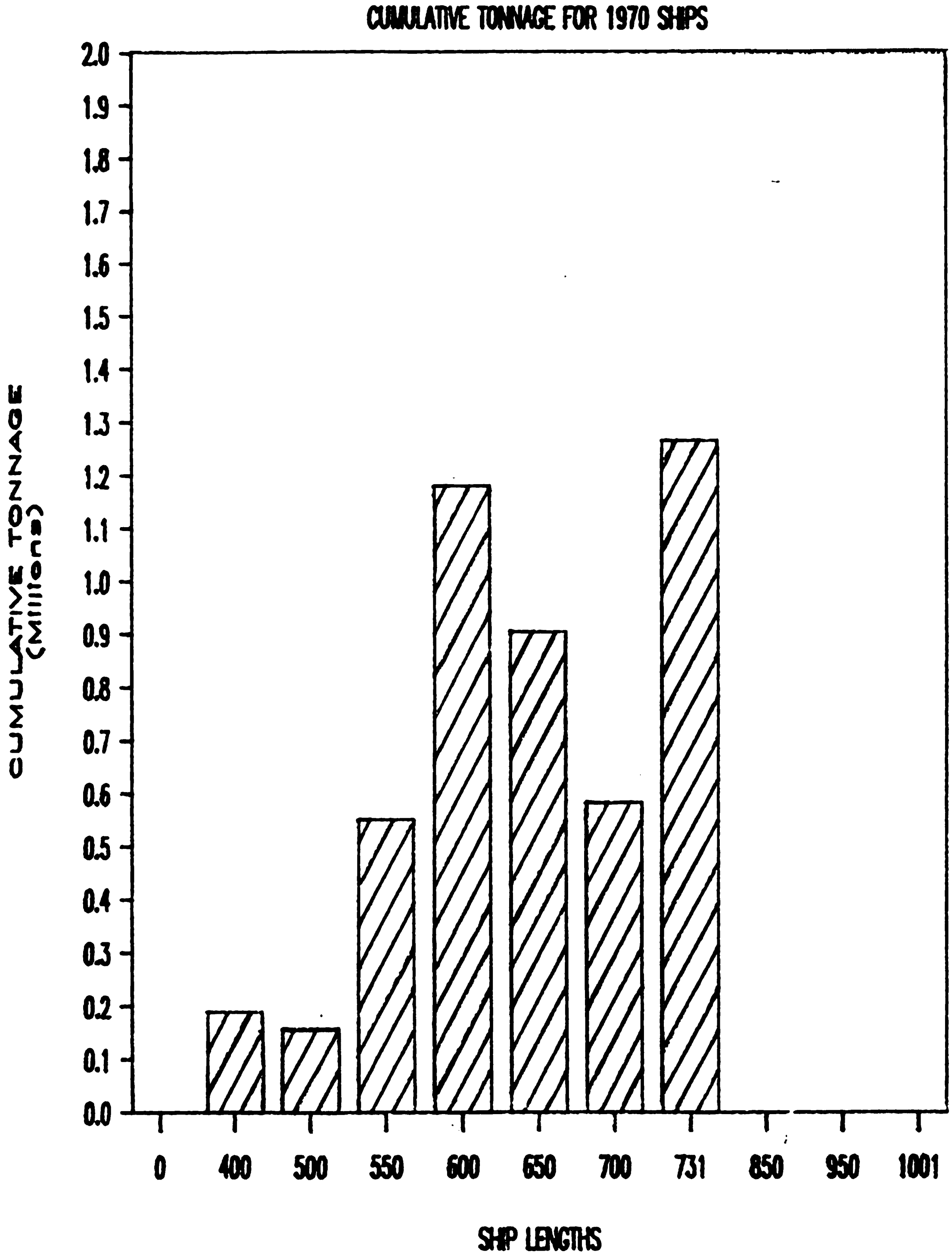

CUMULATIVE TONNAGE FOR 1970 SHIPS
CUMULATIVE TONNAGE (Millions)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
400
500
550
600
650
700
731
850
950
1001
SHIP LENGTHS

Figure VI

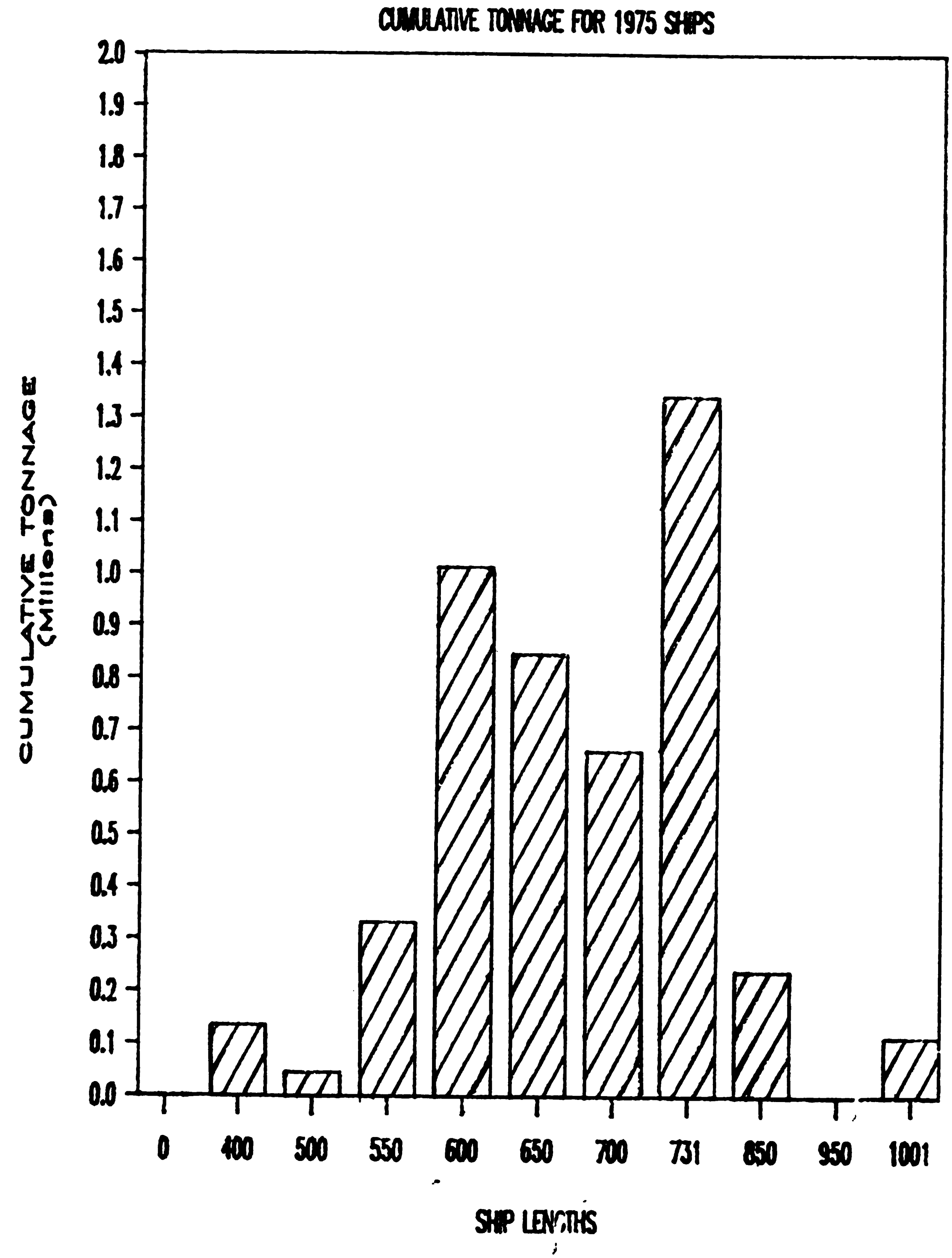

CUMULATIVE TONNAGE FOR 1975 SHIPS
CUMULATIVE TONNAGE (Millions)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
400
500
550
600
650
700
731
850
950
1001
SHIP LENGTHS

Figure VII

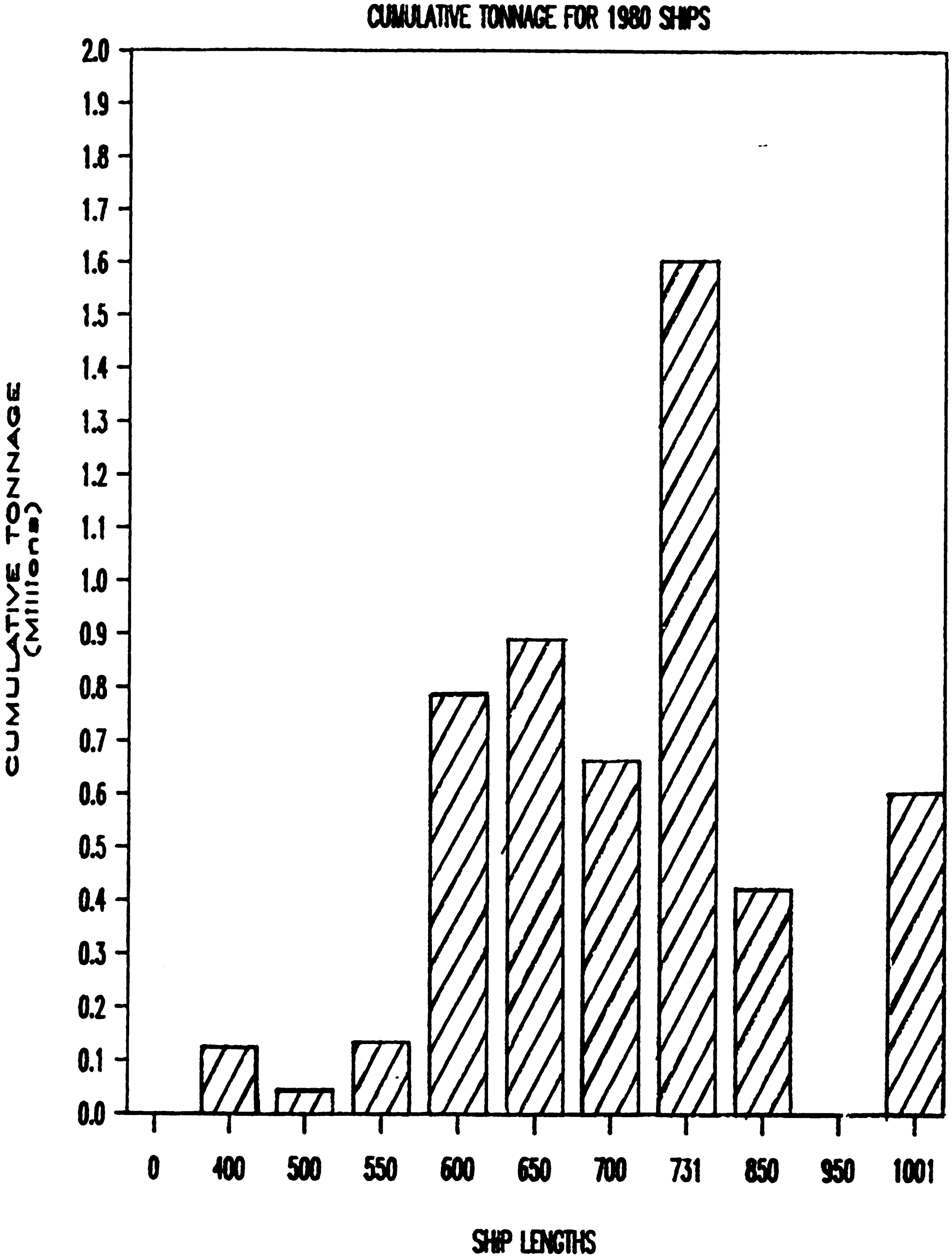
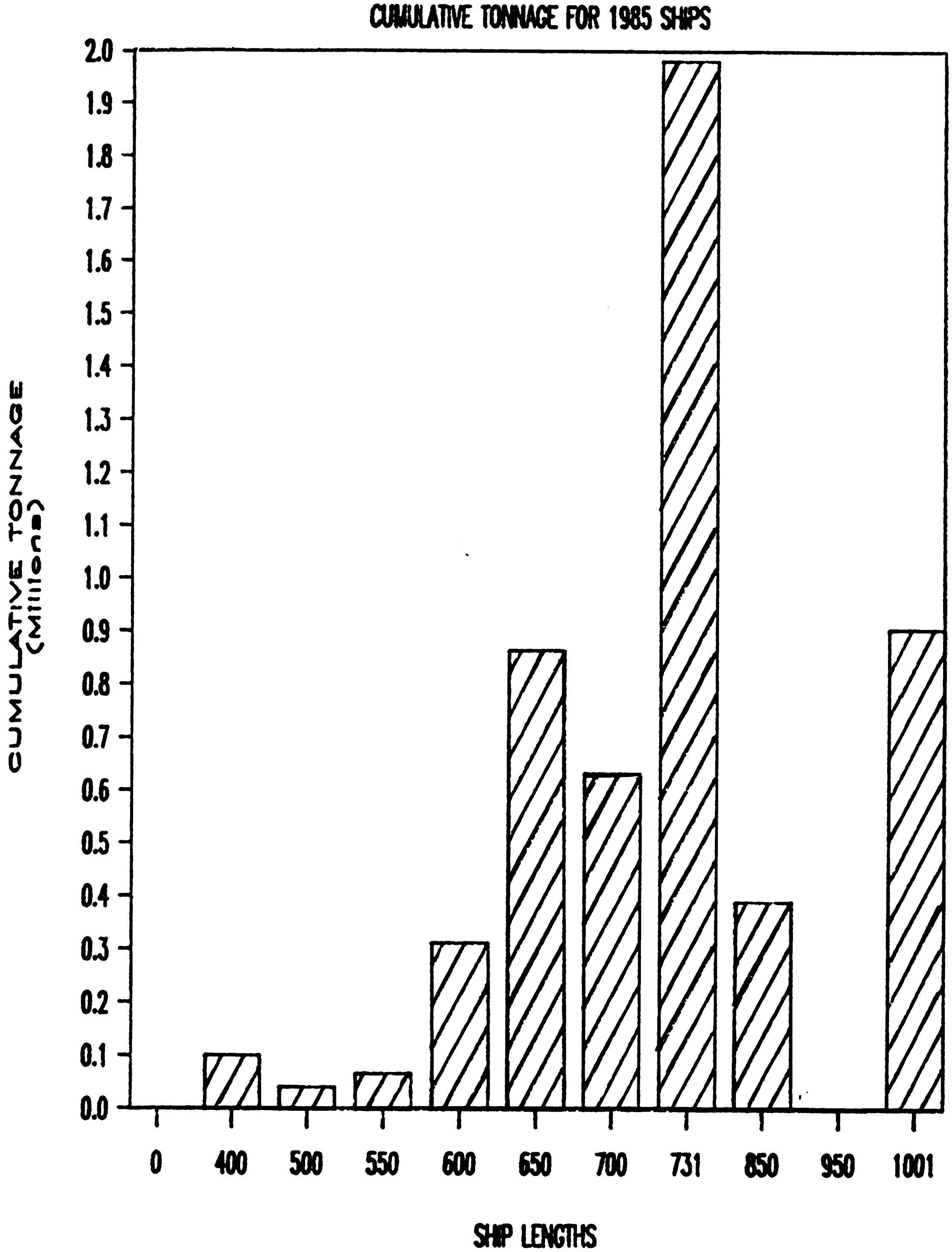

CUMULATIVE TONNAGE FOR 1980 SHIPS
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CUMULATIVE TONNAGE
(Millions)
0
400
500
550
600
650
700
731
850
950
1001
SHIP LENGTHS

Figure VIII


CUMULATIVE TONNAGE FOR 1985 SHIPS
CUMULATIVE TONNAGE
(Millions)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
400
500
550
600
650
700
731
850
950
1001
SHIP LENGTHS

(700-/31 ft.) continued to grow from 58 to 66 ships. Class VIII (731-850 ft.) dropped a bit from 14 to 13 and class X (950-1001 ft.) increased from 9 to 13 vessels. See Figure VIII for the change in cumulative tonnage.

Table III and Figure IX illustrate the effect these changes have had on the average fleet carrying capacity. In 1960 the average tonnage per ship was 8,779 but by 1985 that average had increased to 23,934 tons per ship. Clearly, the trend has been from smaller to larger vessels, i.e., with larger carrying capacity, while at the same time the number of ships in the fleet has declined. The Great Lakes fleet has changed to accommodate the Seaway system and to make the Great Lakes a fourth seacoast.

With all of these changes intended to accommodate the opening of the Great Lakes/St. Lawrence Seaway to wider international traffic, has the fleet's efficiency changed also? By efficiency here is meant the amount of yearly tonnage capacity the fleet has in relation to the actual amount of tonnage shipped. How much overcapacity, if any, is there? If the season is 255 days and a typical thousand footer takes 6.44 days for a round trip, the number of yearly trips it makes is about 40. The fleet's yearly capacity is found by multiplying the number of trips (40) by the fleet tonnage. For example, in 1960, the fleet tonnage was about 5.2 million long tons which gives a yearly fleet capacity of 206.1 million tons (after multiplying by 40). See Table IV for exact values. The actual Great Lakes shipments for that year for the four major bulk commodities of iron ore, grain, coal, and stone was 148.2 million tons. The calculation of "efficiency" is

Table III

AVERAGE SHIP CAPACITY

YEAR	# OF SHIPS	FLEET TONNAGE	AVG. TONS/SHIP
1960	587	5,153,135	8,779
1965	406	4,905,405	12,082
1970	339	4,847,550	14,300
1975	281	4,746,005	16,890
1980	263	5,295,745	20,136
1985	222	5,313,335	23,934

Figure IX

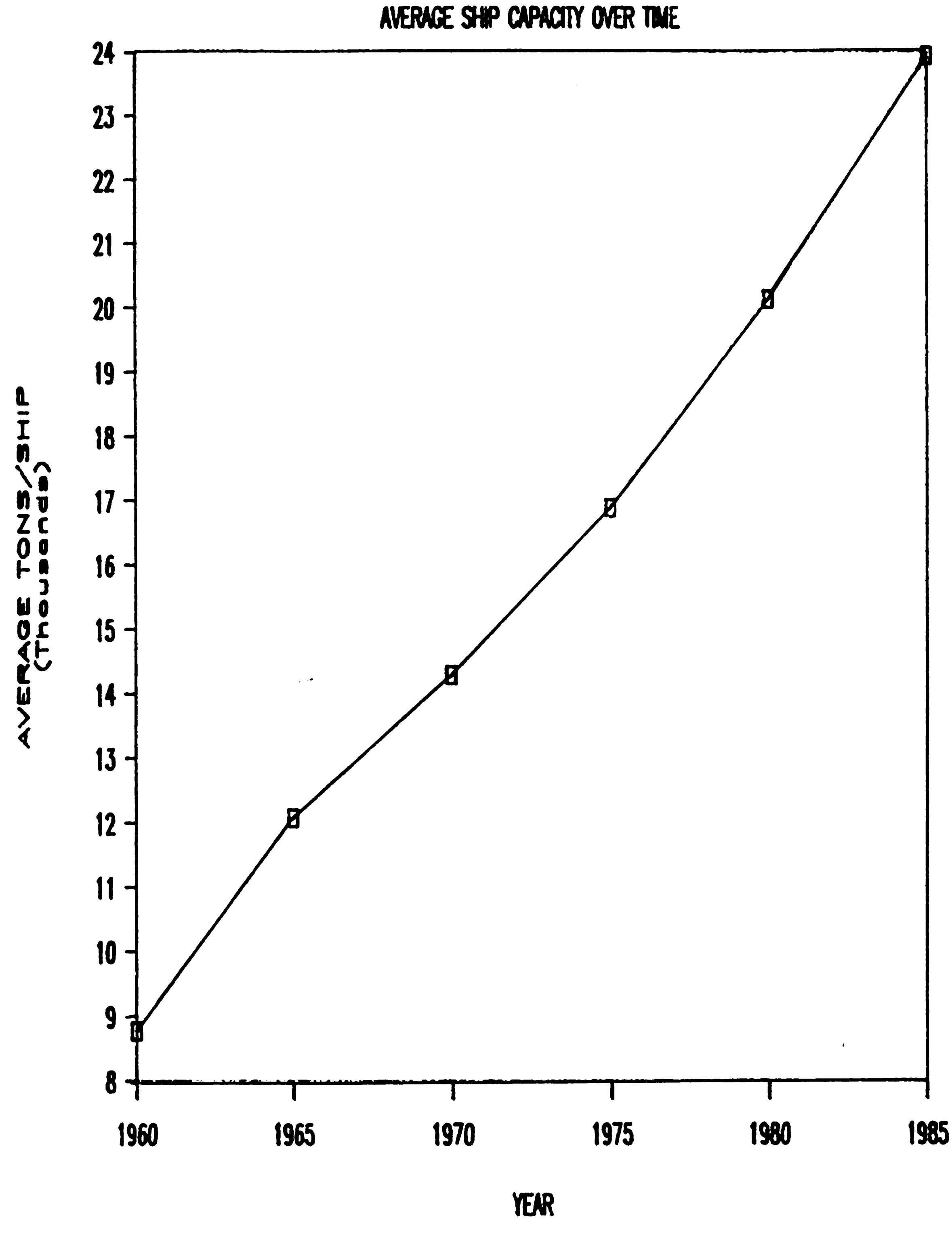

AVERAGE SHIP CAPACITY OVER TIME
AVERAGE TONS/SHIP
(Thousands)
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
1960
1965
1970
1975
1980
1985
YEAR

Table IV

GREAT LAKES FLEET OVERCAPACITY
(in 1000's)

YEAR	FLEET TONNAGE	YEARLY TRIPS	YEARLY CAPACITY	IRON ORE SHIPMENTS*	COAL SHIPMENTS**	GRAIN SHIPMENTS**	STONE SHIPMENTS**	TOTAL SHIPMENTS	OVER-CAPACITY (Ratio)
1960	5,153	40	206,125	69,627	41,698	12,620	24,267	148,212	1.39
1965	4,905	40	196,216	66,545	48,727	19,532	27,517	162,320	1.21
1970	4,848	40	193,902	74,190	44,360	21,268	34,355	174,173	1.11
1975	4,746	40	189,840	80,267	34,993	21,885	33,644	170,790	1.11
1980	5,296	40	211,830	72,629	36,880	28,134	25,010	162,653	1.30
1985	5,313	40	212,533	52,111	32,442	17,907	22,315	124,774	1.70

SEASON (DAYS) 255 SEASON/VOYAGE DAYS = 40 TRIPS PER YEAR

VOYAGE DAYS 6.44

* Source: American Iron Ore Association Annual Reports
** Source: Lake Carriers' Association Annual Reports

All tonnage is given in long tons.

determined by dividing the yearly fleet tonnage by the actual shipments. For 1960, this yields an overcapacity ratio of 1.39, meaning that potential tonnage capacity exceeds actual shipments by about 39%. The following year this overcapacity dropped to 1.21; by 1970, it dropped further still to 1.11 and remained there for 1975. But in 1980 the overcapacity rose to 1.30 and in 1985 again rose to 1.70. During the years 1975, 1980 and 1985 shipping capacity rose while actual shipments were declining for those same years. This suggests that some overcapacity in the fleet exists although the exact amount will be smaller once the minor commodities are included. Table IV is only a first approximation of that measure. The above approximation assumes a constant season for all years and 6.44 round trip days for all vessel classes. Actually, smaller vessels would be able to travel more frequently since they spend less time in port.

The General Accounting Office similarly finds that the U.S. bulk fleet suffers from excess capacity. The report states: "The decline in business conditions on the Great Lakes has resulted in excess capacity in both the American and Canadian fleets." It provides the following table identifying active from inactive vessels for the indicated years:

Table V

U.S. Great Lakes Bulk Fleet Inactivity

Year	Number of Vessels Active	Inactive	Total	Percent inactive
1980	91	56	147	38
1981	104	31	135	23
1982	55	79	134	59
1983	54	80	134	60
1984	63	67	130	52
1985	57	61	118	52

The best information available on the activity of Canadian vessels in 1985 indicates that 35% of the fleet was idle during July and August. Using the GAO figure for the Canadian fleet of 114 vessels that means about 40 ships were inactive and that 74 were used during that time (though their peak season is reported to be in the spring and the fall).[40]

Great Lakes ship owners, then, have sought to take advantage of economies of scale by employing larger but fewer vessels. The effect this has on the cost per ton is presented in the next chapter as a part of a Great Lakes shipping cost model.

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[40] General Accounting Office; Great Lakes Shipping: U.S.-Flag Share of the U.S./Canada Trade on the Great Lakes; Washington, D.C.; May, 1986; pp. 27-28.

CHAPTER V

APPLICATION OF COST MODEL

Explanation of the Cost Sheet

There are different ways in which to work out a cost sheet for shipping depending on the purpose of one's analysis. An engineer, an accountant, and a policy analyst may have three different cost sheets for what is otherwise the same ship, voyage and commodity. Heaver states that: "The relevant cost is always dependent on the purpose for which the costing is to be performed."[41] Hence there are various methods of costing, each emphasizing, omitting or including different factors. An example of different costing estimates arising from different purposes is seen in the decision whether or not to include capital costs. If the purpose is to focus on short-term mainly variable costs, capital costs may be excluded. This may be especially appropriate in the short-term for charter rates under certain market conditions. In the long-run, however, a break-even point or minimum required freight rate is different if capital costs are included.[42]

Another problem in working a cost sheet is the definition of terms used. These may also vary according to the purpose of the analysis.

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41 Heaver, op. cit., p. 35.

42 Ibid., pp. 38-39, 41.

In this study, the cost sheet is laid out in three main sections. At the top the technical assumptions are stated. In the middle the actual cost elements are itemized and broken into four main groups: (1) amortization and interest; (2) operating costs which are further subdivided into fuel, wages, stores/supplies, maintenance/repair, insurance, lay-up, towing, pilotage, port charges and "other"; (3) overhead; and, finally (4) tolls, lockage fees and user fees. The third and final section of the cost sheet is a simple three-item statement of the results: (1) the total trip cost; (2) the cost/ton; and (3) the ton-miles/gallon. The cost/ton is understood to mean the minimum required freight rate that must be charged in order for the owner to stay in business in the long run. The definitions of the terms will be made clearer in the following sections.

Technical Assumptions

Under the heading "Technical Aspects" the cost sheet itemizes just what sort of vessel is being assumed and the route it takes. The Great Lakes vessels are divided into ten length classes similar to that of the Corps of Engineers. For example, a vessel class X is a ship that is 950-1000 feet long as measured between its perpendiculars (BP).

The tonnage is given as long tons and reflects the average deadweight tonnage for 1985 ships derived from an analysis of data in Greenwood's. The carrying capacity and the deadweight tonnage are essentially the same for iron ore since the density of the cargo is great enough to allow a ship to reach very nearly its maximum (deadweight) carrying capacity.

The speeds for all ship sizes differ very little. In this study the specific values are taken to be the same for all vessel sizes.[43]

The distances for voyages within the Great Lakes system is taken from Greenwood's (1985). The route assumed is from Two Harbors, Minnesota to Chicago and is given as 785 statute miles from breakwater to breakwater.

Since significant portions of the Great Lakes are frozen during winter, shipping ceases between December and April. It is reasonable to assume 255 days as a normal season, though it can at times reach 260 or 270 days. In this study 255 days was assumed as a variable input. The loading rate is 6,000 long tons per hour for Two Harbors as found in the Corps of Engineers report on ports and harbors.[44] The unloading rates vary with the size and type of vessel. In this study all vessels are assumed to be diesel self-unloaders and can discharge their cargos rather quickly.

Both steam turbines and diesel engines are used on the Great Lakes. However, since many, if not most, are diesels and since this is the trend of present ship design, the study here always assumes diesel engines.

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[43] Benford, Harry. 1987. University of Michigan, Department of Naval Architecture and Marine Engineering. Personal communication.

[44] U.S. Army Corps of Engineers, Port Services No. 49 (Revised 1987): The Ports of Duluth, MN, and Superior, WI, Taconite Harbor, Silver Bay, and Two Harbors, MN, and Ashland, WI; prepared by the Water Resources Support Center; p. 57.

This does not affect the flexibility of the cost sheet, however. If one desires to model a steam turbine, one need only change the relevant input variables key among which are the daily fuel consumption rates and the price per gallon, and possibly the maintenance and repair value.

The formulae used to calculate fuel costs per day and per trip are complex. They distinguish between fuel consumed "in port" and "at sea" and reflect differences both in rates of consumption and in prices per gallon, when appropriate, for different grades of fuel. Fuel consumed "in port" involves a further breakdown reflecting differences in fuel consumption rates to operate cargo unloading equipment on the one hand and to run the ship's electrical systems on the other (lights, radar, computers, etc.). Another branching occurs under the heading "at sea," namely, fuel needed to drive the main propulsion plant and to run also the generators for the ship's electrical systems.

The expression "port days" refers to the time spent in port loading and unloading. While loading up, the ship uses only its electrical systems and so consumes a relatively small amount of fuel. How much time is spent loading depends on the port facilities. Unloading is a function of on-board equipment and thus both time and fuel used are dependent on the machinery needed to operate the conveyor belt system. Fuel consumption here is also dependent on that used for running the electrical systems.

Other sources in modelling ship fuel consumption rates, though, are often not as detailed. For example, the Maritime Administration reports on only fuel consumed "at sea" and "in port" with no differentiation between fuel consumed for the conveyor versus the electrical systems. For a thousand footer, for instance, the DFC "at sea" is 410 bbls. (or about 17,220 gallons) while "in port" consumption is given at 45 bbls. (or about 1,890 gallons) which presumably includes both electrical and conveyor system operations.[45] Both fuel consumption rates are a little high judging from consumption rates used in this study based on interviews with private companies.

For a vessel class V (647 ft. overall length) the Maritime Administration reports a daily fuel consumption "at sea" as 275 bbls. (11,550 gallons) and "in port" 50 bbls. (2,100) gallons).[46] The fuel consumption rate "at sea" is a little high compared to values used here.

Another shipping study by Data Resources, Inc. (DRI) also breaks down fuel consumption rates at no more than "at sea" and "in port."[47] For a 15,000 DWT ocean going vessel the study gives an "at sea" daily fuel consumption value of 330 bbls and for "in port" 35 bbls. (or 13,860 gallons and 1470 gallons respectively). For a 60,000 DWT vessel the report gives 432 bbls. at sea and 40 in port (or 18,144 gallons and 1680 respectively). An 80,000 DWT ocean going vessel consumes 459 bbls. at sea and 45 in port (or 19,278 gallons and 1,890 gallons respectively).

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[45] Maritime Administration; Estimated Vessel Operating Expenses 1984; U.S. Department of Transportation, Office of Ship Operations; Washington, D.C. (May, 1986).

[46] Ibid.

[47] Data Resources, Inc. Ocean Vessel Costing, pp. B-29, B-32.

Buxton, on the other hand, gives a formula very similar to the one used here. Using an annual approach, the equation is:

> (Main engine tonnes per day x ME fuel price per tonne + auxiliary tonnes per day at sea x auxiliary fuel price per tonne) x days at sea per annum + auxiliary tonnes per day in port x auxiliary fuel price per tonne x days in port per annum.[48]

The main difference is that he makes no distinction between "auxiliary" (electrical systems) and conveyor consumptions, or more broadly between in port loading and in port unloading. This may be appropriate for some ocean vessels but not for Great Lakes carriers hauling iron ore.

Fuel consumption rates for operating the conveyor and electrical systems vary. Buxton writes that the auxiliary loads in port for ocean bulkers at sea may range from 400 to 500 KW corresponding to a daily fuel consumption of about 2 tonnes.[49] The Belle River uses two separate generators to service its electrical systems rated at 600 KW maximum output each. Assuming the lower value in the ratio of KW to Tonnes given above (i.e., 400 KW = 2 tonnes of fuel), then each of these two generators consumes about 3 tonnes of fuel a day. Assuming 322 gallons per long ton[50] this translates to 966 gallons a day and a

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48 Buxton, Ian L.; "Fuel Costs and Their Relationship with Capital and Operating Costs" in Maritime Policy and Management, Vol. 12, No. 1 (1985): 50.

49 Ibid., p. 52.

50 Swift, Peter M., Volker H. Elste and Benedict J. Stallone; Great Lakes Winter Navigation - Technical and Economic Analyses Annex: Methods of Evaluation and Computer Program; Department of Naval

bit over 40 gallons an hour. The Lewis Wilson Foy[51] and the William J. DeLancey[52] both have generators each with a capacity of 800 KW and making the same assumptions, this corresponds to around 1300 gallons a day or 54 gallons an hour. To unload the Belle River possesses two generators with 2,500 KW capacity[53] corresponding to about 12.5 tonnes of daily fuel consumption which translates into 3,864 gallons a day or around 161 gallons an hour.

In this study, based on an interview with a Great Lakes company, the operation of the conveyer system to unload the cargo is assumed to have a daily fuel consumption of about 3,000 gallons for a vessel class X. (While no specific assumptions concerning generator type are made, this would correspond approximately to two generators of 900 KW each consuming a total of 120 gallons an hour or 60 gallons an hour each. This gives a literal daily fuel consumption of 2,880 gallons). For vessel classes VII and V, the consumption rates are taken to be 2,500 and 2,100 respectively.

Maneuvering time of one hour at each dock is allowed and two hours to travel through the Soo Locks and St. Mary's River. This is admittedly a rough model of ship activity but is in keeping with the

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Architecture and Marine Engineering; University of Michigan, Ann Arbor, Michigan 48104; (December, 1974), p. 10.

51 Miller, Robert H.; Great Lakes Thousand Footers; Bay Shipbuilding Corp., Sturgeon Bay, Wisconsin; May 18, 1979.

52 See brochure for Pickands/Mather on the William J. DeLancey. Cleveland, OH.

53 Miller, op. cit.

philosophy described above eschewing complicated, detailed tracking of all ship action. The effect on cost is negligible.

The cargo tonnage is sometimes restricted not by the dimensions of the ship but by the permissible draught of the channel. In certain times of the year this is true of the Neebish Channel. Its maximum allowable draught is 27 feet. If a typical self-unloader had an immersion factor 237.5 long tons per inch of immersion its maximum cargo tonnage would be 76,950 long tons, about as big as a thousand footer can get today.[54] The tonnage value assumed here is an average figure of 69,712 tons and corresponds to a draught of just under 24-1/2 feet.

Cost Elements

One of the most important and difficult cost figures to determine is the price of a new ship. Under the heading "The nebulosity of ships' capital costs" Peter S. Douglas of the Chase Manhattan Bank (London) emphasized the problem of estimating capital costs. He argues that the market is highly volatile, showing great variations in shipbuilding prices over relatively short periods of time. The same situation arises for second-hand prices of used ships. The determination of freight rates, then, is difficult because this important component is elusive.

On the other hand, freight rates themselves influence capital costs. As he states: "Indeed, there exists a continuing iterative

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[54] Miller, op. cit. and Swift, op. cit. p. 9.

process between freight rates, second-hand values and newbuilding prices which, to my knowledge, has never been reduced to a formula which actually works in the real world".[55] Given such conditions shippers "spend very little time trying to quantify the capital cost component of a ship's total operating cost unless they are in the liner business or are bidding for very long-term employment of their vessels".[56] Instead such entrepreneurs focus on "direct running costs" and calculate the capital costs in an after-the-fact manner: "Once a vessel is bought...its capital cost over time will not be known until it is sold".[57]

What then are the real capital costs of new ships according to Douglas? They are the sum of the payments to be made under a loan agreement or lease plus all the other resources needed to obtain that lease or loan. "These other resources are not easily quantifiable...".[58] In fact there are formidable obstacles to generalizing a method for comparing capital costs when most of the world's fleets are employed on a short-term basis. Along with liner vessels, he excepts bulkers under long-term employment. But he writes that these comprise barely 25% of the vessels in the world trade. He writes: "In any case, the prognosis for deriving a commonly-accepted

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55 Douglas, Peter S.: "The Effects of Ship Financing and Leasing on the Measurement of Shipping Costs" in Maritime Policy and Management, Vol. 12, No. 1 (1985): 29.

56 Ibid.

57 Ibid.

58 Ibid., p. 33.

approach to quantification of capital costs over time from analysis of this segment of the fleet is not encouraging".[59]

Benford, on the other hand, explicitly references the capital recovery method for use in estimating capital costs. He suggests a capital recovery factor (CRF) of at least 12% and makes no particular criticism of the method.[60]

The "nebulosity" of capital costs arises, however, from the introduction of the concept of opportunity cost. This concept is not an accounting cost which is easier to track. Instead, it is a negative cost, referring to that which is not but which might have been. Unlike the positive idea of an accounting cost which refers to that which is, no one demands payment. The concept is also highly subjective in that a comparison of all alternative opportunities involves a personal weighing and judgment about relevant benefits. Perhaps in part for this reason Dobb refers to the concept as "shadowy" and "contingent".[61] In this paper, therefore, the accounting concept of cost is used and presents no formidable difficulties for meaningful and practical capital cost estimates.

Though the particular capital costs vary from vessel to vessel as do the financing arrangements, the object here is to present a typical picture of the overall fleet which is reasonably accurate even though it may differ from actual costs for any one ship. To indicate the

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59 Ibid., p. 34.

60 Benford, op. cit., p. 23.

61 Dobb, Maurice; Theories of Value and Distribution Since Adam Smith, Cambridge University Press (1973), p. 170.

variation in capital costs, that is actual ship prices, a review of the published or estimated costs will prove instructive.

For example, in the Extended Season Program (1974) composed by a team from the Department of Naval Architecture and Marine Engineering at the University of Michigan, the authors use a value of $36 million for the price of a 1000 footer. For a 730 footer they use a value of $16 million.[62] On the other hand, the International Lake Erie Regulation Study Board uses a figure of $74 million and $37 million, respectively, for the same length of vessels.[63] A more recent study by Touche Ross & Co. used 1984 costs for acquiring new vessels built in Canada and worked with a value of $44 million for a Seaway-sized ship (i.e., 730 feet long).[64] Sussman, though, claims that new 730 foot self-unloaders cost over $25 million (Canadian) in 1975.[65]

The values used in this study for Great Lakes vessels are derived or composed from personal interviews directly with representatives of private firms. These sources sometimes revealed explicit costs and purchasing prices for specific ships. Thus one of the earliest thousand footers was delivered in 1972 and sold for $19 million. But over time the cost of such vessels increased and a range of costs

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[62] Swift, et al. op. cit., pp. 23, 31.

[63] International Lake Erie Regulation Study Board, op. cit., p. D-38.

[64] Touche Ross and Co.; Great Lakes Shipping: A Financial Profile 1977-1984; A Report to the Dominion Marine Association (January, 1986), p. 22.

[65] Sussman, Gennifer; The St. Lawrence Seaway: History and Analysis of a Joint Water Highway; Canada-U.S. Prospects sponsored by C.D. Howe Research Institute (Canada) and the National Planning Association (U.S.A.), 1978; p. 38.

obtained from $37 to $56 million where the later vessels built sold near the higher end of this range. For a thousand footer, then, the cost sheet uses an intermediate value of $47 million.

For a maximum Seaway-sized vessel of 730 feet, one private source approved $37 million as a replacement cost. But this was balanced against Sussman's value of $25 million (Canadian) in 1975 for such a vessel. Again an intermediate figure of $30 million is used.

For vessel class V, no good estimates were available. These ships are usually older vessels and are not the major haulers of iron ore. Their original purchasing price is estimated to be about $20 million.

The construction cost figures for all classes of Great Lakes vessels are taken from the private sources. The interest rate is taken from private sources and for all classes of ships is an average 11% per annum.

The familiar capital recovery method is used to calculate the uniform yearly payment. Based on the principal, the interest rate and the expected years of finance a yearly payment is determined in the same way a monthly payment on a car loan is derived. This yearly figure is then divided by the season days (255) to give a daily cost. The daily cost is then multiplied by the voyage days to yield the one way trip cost.

Operating costs are listed next beginning with the price of fuel. There is normally one price for the heavier fuel to operate the main engines and another price for the lighter fuel to operate the generators.

Often the difference in cost between lighter and heavier fuels is negligible and one common price is used. In this case, 59 cents per gallon is used for both.

The equation describing the relationships "at sea" and used to determine daily fuel cost is:

$$DFC_s \cdot P_s + DFC_g \cdot P_g \text{ where}$$

DFC_s = daily fuel consumption at sea in gallons for main engines

DFC_g = daily fuel consumption for the generators in gallons to run electrical systems

P_s = price of heavy blend diesel fuel per gallon

P_g = price of light diesel fuel for the generators per gallon.

The total one-way trip cost is found by multiplying the daily cost by the "sea days." The sea days are determined by subtracting "port days" from the "voyage days."

The equation for "in port" daily consumption is given as:

$$DFC_c \cdot P_g + DFC_g \cdot P_g \text{ or}$$

$$(DFC_c + DFC_g)\ P_g \text{ where}$$

DFC_c = daily fuel consumption in gallons when operating the conveyor and

DFC_g = daily fuel consumption in gallons to operate electrical systems.

The cost for the entire trip time, i.e., the entire time spent "in port" is described as:

$$(DFC_c \cdot \text{Unloading Days} + DFC_g \cdot \text{Port Days})\ P_g$$

$$= (DFC_c \cdot \frac{t/u}{24\ \text{hrs.}} + DFC_g \cdot \frac{(t/l + t/u + c)}{24\ \text{hrs.}})\ P_g$$

where,

t = tonnage

u = unloading rate in long tons per hour

l = loading rate in long tons per hour

c = constant to represent docking and locking time.

The next cost item is crew wages. These can include varying elements. Frankel, for example, includes direct wages, pensions, vacation pay, health insurance, sick leave pay, food, travel costs to and from vessel, and so on. Excluded, often, are capital and maintenance costs for crew accommodations; crew administration and replacement; medical expenses not covered by insurance, etc.[66] In the present study crew wages have been taken from estimates given by actual

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66 Frankel, Ernst G.: Management and Operations of American Shipping; Auburn House; Boston (1982); p. 160.

Great Lakes shipping companies. Wages include base wage, overtime, all fringes, FICA, and payroll deductions.

Normally, officers receive more pay than unlicensed seamen but how much more varies with each company and according to labor union contracts with that company. Thus, one shipping firm pays its officers twice what it pays its seamen (2:1) even though the officers make up only 1/3 of the total crew size.

For a vessel class X (950-1000 ft.), the average wage per man per day is $247 with a crew of 30 which amounts to about $7400 per day (see Exhibit 1). For the vessel class VII (700-730 ft.) the daily crew is set to around $6500 and assuming a crew size of 27, averages $241 per man per day (Exhibit 2). This is true for a vessel class V also (Exhibit 3).

A ship's insurance costs normally include protection and indemnity (P&I); hull insurance; and often but not always cargo insurance. P&I insurance covers third party liabilities and certain contractual liabilities and is roughly similar to PL/PD for car insurance; hull insurance covers damages and repairs to the hull. Cargo insurance protects against loss or damage to the cargo. The values used for insurance for the vessel classes X, VII and V are: $1,118, $353, and $353 respectively.

The costs for stores and supplies, maintenance/repair and insurance are taken from a Maritime Administration publication[67] and from interviews with private sources. The values for stores/supplies for these vessel classes, again in order of decreasing size, are:

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[67] Maritime Administration, op. cit.

$800, $500, and $500. The figures for maintenance/repair for these same vessel classes are: $1,273, $300, and $300 respectively.

Towing, pilotage and port charges are taken from Booz, Allen and Hamilton[68] and from directly a private source. With the exception of a trivial towing charge of $500/trip for vessel classes V and VII, these fees normally apply only for ocean vessels.

The miscellaneous category "other" is also taken from the Maritime Administration and accepted by private sources.[69] It is set at 95 dollars for all three vessel sizes.

For the calculation of overhead which includes such things as administration, brokerage fees, etc., the LER study approach was used for taking 12% of the operating costs and accepted by all private companies interviewed.[70] For a one-way trip this equals $6,373 for vessel class X, $4,167, for a vessel class VII and $4,018 for vessel class V.

Lay-up fees are paid for Great Lakes vessels which are idled during the winter months. The specific cost estimates are based on information from private companies. For vessel class X the annual lay-up fees amount to $150,000 which equals about $588 a day. For the other two classes this amounts to $431 a day and $110,000 a year.

The 1986 Water Resources Development Act imposes an ad valorem charge on the cargo carried on U.S. Great Lakes ships. The law

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[68] Booz, Allen and Hamilton, Inc.; Transportation Cost Analysis of the St. Lawrence Seaway; April 15, 1985, p. 23.

[69] Maritime Administration, op. cit.

[70] International Lake Erie Regulation Study Board, op. cit., p. D-38.

requires that a tax of .04% be imposed on each dollar market value. In the cost sheet this is reflected by the use of a posted price of $38/long ton multiplied by the factor of .0004 to derive the user fee.

The next cost element is tolls. The ship incurs toll charges when passing through the St. Lawrence Seaway System, namely, through Montreal and through the Welland Canal. The tolls come in two types: charges levied against gross registered tonnage which obtains regardless of whether the ship is loaded or empty; and charges levied against the cargo tonnage. The cost sheet reflects charges levied both ways against the gross registered tonnage and one way for the charges against cargo tonnage. Current values for these fees are found in Greenwood's. At Montreal the charge against gross (long) registered tons is $0.08/ton while at the Welland Canal it is $0.09/ton. The charge against the cargo at Montreal is $0.84/long ton and at the Welland it is $0.38/long ton.

Lockage fees are also levied for the eight locks at the Welland Canal at $250/lock and apply whether the vessel is loaded with cargo or not.[71] Thus, the one-way trip cost is $2,000 and round trip is $4,000.

Exhibit 4 illustrates the effect of tolls and lockage fees through the Seaway on cost. The distance reflects the route from Two Harbors to Montreal in a 730 foot vessel. The other cost elements are the same as for the route from Two Harbors to Chicago. (Of course, the specific trip values reflect the increased distance.)

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[71] Anonymous; "Rail and Lake Freight Rates on Iron Ore and Pellets per Gross Ton," in Skillings Mining Review, Vol. 75, No. 4 (January 25, 1986): 19.

Results

The last third of the cost sheet states the results of these calculations. The total cost is the total cost of the trip one way. The cost/ton is simply the total (one way) trip cost divided by the tonnage. This, too, is a one way figure. For a round trip this value is simply doubled. The effect of a ballast backhaul on fuel is negligible and the remaining values are the same. In the calculation of tolls the cost/ton figure is doubled and the charges against the cargo are subtracted out. The total one way trip costs in order of decreasing vessel size are: $130,982 (Exhibit 1); $78,659 (Exhibit 2); and $62,696 (Exhibit 3). Their one way costs/ton are, respectively: $1.88; $2.58; and $3.33. Their round trip costs/ton are: $3.74; $5.14; and $6.64. For the special case of the Seaway route, the total one-way trip cost is $168,921 (Exhibit 4). The one-way cost/ton is $5.54 and the round trip cost/ton is $9.84.

Finally, the technical measure of the efficiency is given as ton-miles/gallon. This indicates the fuel-efficiency of the ship and is the same whether one considers a trip one or both ways. The calculation is based on the multiplication of tonnage times distance divided by the total number of gallons consumed on the trip. This calculation is a "measure" of merit based on technical rather than economic grounds. It is a reflection of the fuel efficiency and economies of scale of a vessel and reveals how many tons of cargo the vessel moves one mile on one gallon of fuel. This is arithmetically calculated as the tonnage times the miles travelled divided by the gallons of fuel consumed. Often, the gallons consumed includes the entire round trip, even though the cargo is moved only one way. This is intended to account for the backhaul of ballast from the lower lakes to the head of lakes, say going back "empty" from Chicago to Two Harbors.[72]

This formula is slightly modified in the present cost sheet calculation. The fuel consumed reflects only the fuel used to move the cargo one way: Two Harbors to Chicago. As a result the values of ton-miles/gallon tend to be twice as high as other calculations. Though the absolute values are thus different, no difference obtains comparatively, i.e., if vessel A is twice as efficient as vessel B, this conclusion is the same by either calculation.[73]

In the three cost sheets used the ton-miles/gallon values are as follows: 2,091 for a thousand footer; 1,373 for a 730 footer and 848 for a 650 footer. (Using the more common method these values would be

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72 Swift, et al., op. cit., pp. 9-10.

73 There are two main reasons, though, why the commonly accepted calculation is rejected here. First, the common method contradicts the purpose of the measure. The whole point is to obtain a measure of technical efficiency that is independent of economic or market values and fluctuations. These should reflect the efficiencies of fuel consumption and economies of scale, not the accident of geography or traffic routing management. Secondly, the motivation of the method is to "account" for the fuel consumption of the backhaul; to "charge" it against something. Again, this desire to account or charge is an economic motive. Yet there is no reason to "charge" the return fuel consumption to the one-way movement of iron ore: it is not the ship's fault that Chicago has no coal to bring back. The fuel consumed on the back-haul is used to carry ballast water, but from a purely technical perspective it is just as meaningful to consider how many ton-miles of ballast water/gallon is needed as of iron ore. The substance carried is immaterial here.

halved to 1,046, 687 and 424 respectively.) The efficiency of the 730 footer for its Seaway trip is, of course, the same.

These calculations compare well with others in the literature. For example, Iron Age reports that the William DeLancey consumes 70,000 gallons on a six day round trip and carries 56,000 long tons of cargo.[74] If the DeLancey travels at its maximum speed when loaded of 15.5 mph, then in three days it travels about 1100 miles one way.[75] This means the

$$\text{Ton-miles/gallon} = \frac{56000 \cdot 1100}{70{,}000}$$

$$= 880 \text{ (or 1760 when doubled).}$$

Differences arise in these figures due to differences in tonnage capacity and fuel consumption rates assumed. Using 60,500 long tons in the above equation (cited by Pickands/Mather as a typical iron ore load) yields a value of 950 ton-miles/gallon (1900 when doubled) with no change in the daily fuel consumption rate.[76] In this study an average DWT for thousand footers of 69,712 long tons is derived from Greenwood's. The distance traveled is 785 statute miles and the fuel consumed one way is about 26,160 gallons.

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74 Weimer, George A.: "Era of 1000-ft. Ore Boats Dawns on the Great Lakes" in Iron Age, January 4, 1982; p. MP-27.

75 Pickands/Mather Brochure, op. cit.

76 Ibid.

The formula for ton-miles/gallon can be restated so as to exclude any direct reference to distance, and hence a particular route, and to total fuel consumed. It may instead be expressed as:

$$\text{Ton-miles/gallon} = \frac{\text{tonnage} \cdot \text{speed: 24 hrs.}}{\text{Daily fuel consumption at sea}}$$

Using the data for a 650 footer in this study gives:

$$\text{Ton-miles/gallon} = \frac{18{,}855 \cdot 15 \text{ mph} \cdot 24 \text{ hrs.}}{8{,}000}$$

$$= 848.$$

The most important comparative results are the round trip costs/ton and the ton-miles/gallon. These results will be tabulated and compared with other results in Chapter VIII. But before this, a review of the ocean costs will be given in the next chapter.

Exhibit 1

TWO HARBORS COST SHEET

TECHNICAL ASPECTS:

Vessel Class 10:	950-1000ft	Loading rate:	6,000
Tonnage:	69,712	Unloading rate:	7,500
Speed:	15.00	DFC in port: 350	3,000
Distance:	785.00	DFC at sea:	12,000
Voyage Days:	3.22	Days in port:	1.04
Season (days):	255	Engine type:	Diesel

				DAILY	TRIP
AMORTIZATION & INTEREST:		5,580,791 /yr		21,885	70,441
Constr.$:	Int.:	Years:			
47,000,000	0.11	25			
OPERATING COSTS:					
FUEL($/G):	at sea:	0.59	/.59	7,287	15,889
	in port:	0.59		1,977	900
WAGES:	avg/man:	247		7,410	23,850
	crew #:	30			
STORES/SUPPLIES:				800	2,575
MAINT/REPAIR:				1,273	4,097
INSURANCE:				1,118	3,598
LAY-UP:	Annual $:	150,000		588	1,893
TOWING:				0.00 /LT	0
PILOTAGE:				0.00 /LT	0
PORT CHARGES:				0.00 /LT	0
OTHER:				95	306
OVERHEAD (12% OF OC):				2,466	6,373
USER FEES:	0.0004	38			$1,060
TOLLS:					

TOTAL COST:	$130,982	One Way
COST /TON:	$1.88	One Way
	$3.74	Round Trip
TON-MILES/GALLON:	2,091	Either Way

Exhibit 2

TWO HARBORS COST SHEET

TECHNICAL ASPECTS:

Vessel Class 7:	700-730ft	Loading rate:	6,000
Tonnage:	30,512	Unloading rate:	5,000
Speed:	15.00	DFC in port: 350	2,500
Distance:	785.00	DFC at sea:	8,000
Voyage Days:	2.81	Days in port:	0.63
Season (days):	255	Engine type:	Diesel

					DAILY	TRIP
AMORTIZATION & INTEREST:			3,562,207	/yr	13,969	39,301
Constr.:	Int.:		Years:			
30,000,000	0.11		25			
OPERATING COSTS:						
FUEL($/G):	at sea:		0.59	/.59	4,927	10,743
	in port:		0.59		1,682	506
WAGES:	avg/man:		241		6,507	18,307
	crew #:		27			
STORES/SUPPLIES:					500	1,407
MAINT/REPAIR:					300	844
INSURANCE:					353	993
LAY-UP:	Annual $:		110,000		431	1,214
TOWING:					0.00 /LT	500
PILOTAGE:					0.00 /LT	0
PORT CHARGES:					0.00 /LT	0
OTHER:					95	267
OVERHEAD (12% OF OC):					1,775	4,174
USER FEES	0.0004		38			464
TOLLS:						

TOTAL COST:	$78,718	One Way
COST /TON:	$2.58	One Way
	$5.14	Round Trip
TON-MILES/GALLON:	1,373	Either Way

Exhibit 3

TWO HARBORS COST SHEET

TECHNICAL ASPECTS:

Vessel Class 5:	600-649ft	**Loading rate:**	6,000
Tonnage:	18,855	**Unloading rate:**	4,000
Speed:	15.00	DFC in port: 350	2,100
Distance:	785.00	DFC at sea:	8,000
Voyage Days:	2.67	Days in port:	0.49
Season (days):	255	Engine type:	Diesel

				DAILY	TRIP
AMORTIZATION & INTEREST:		2,374,805	/yr	9,313	24,908
Constr.$:	Int.:	Years:			
20,000,000	0.11	25			
OPERATING COSTS:					
FUEL($/G):	at sea:	0.59	/.59	4,927	10,743
	in port:	0.59		1,446	345
WAGES:	avg/man:	241		6,507	17,403
	crew #:	27			
STORES/SUPPLIES:				500	1,337
MAINT/REPAIR:				300	802
INSURANCE:				353	944
LAY-UP:	Annual $:	110,000		431	1,154
TOWING:				0.00 /LT	500
PILOTAGE:				0.00 /LT	0
PORT CHARGES:				0.00 /LT	0
OTHER:				95	254
OVERHEAD (12% OF OC):				1,747	4,018
USER FEES:	0.0004	38			287
TOLLS:					

TOTAL COST:	$62,696	One Way
COST /TON:	$3.33	One Way
	$6.64	Round Trip
TON-MILES/GALLON:	848	Either Way

Exhibit 4

SEAWAY COST SHEET

TECHNICAL ASPECTS:

Vessel Class 7:	700-730ft	Loading rate:	6,000
Tonnage:	30,512	Unloading rate:	5,000
Speed:	15.00	DFC in port: 350	2,500
Distance:	1,320.00	DFC at sea:	8,000
Voyage Days:	4.55	Days in port:	0.88
Season (days):	255	Engine type:	Diesel

					DAILY	TRIP
AMORTIZATION & INTEREST:			3,562,207	/yr	13,969	63,554
	Constr.$:	Int.:	Years:			
	30,000,000	0.11	25			
OPERATING COSTS:						
	FUEL($/G):	at sea:	0.59	/.59	4,927	18,064
		in port:	0.59		1,682	557
	WAGES:	avg/man:	241		6,507	29,604
		crew #:	27			
	STORES/SUPPLIES:				500	2,275
	MAINT/REPAIR:				300	1,365
	INSURANCE:				353	1,606
	LAY-UP:	Annual $:	110,000		431	1,963
	TOWING:				0.00 /LT	500
	PILOTAGE:				0.00 /LT	0
	PORT CHARGES:				0.00 /LT	0
	OTHER:				95	432
OVERHEAD (12% OF OC):					1,775	6,764
USER FEES:		0.0004	38			464
LOCKAGE FEES:		$250/lock	eight locks			2,000
TOLLS:	0.08	0.09	15000			39,775
	0.84	0.38				

TOTAL COST:	168,921	One Way
COST /TON:	5.54	One Way
	9.84	Round Trip
TON-MILES/GALLON:	1,373	Either Way

CHAPTER VI

OCEAN COSTS

The cost analysis for iron ore shipped on the oceans will be presented in this chapter. The structure of the cost model is the same but the specific values are different. Often these values had to be interpolated from information derived from the literature or from personal interviews with various individuals involved in the shipping industry. These values are not as reliable as those of the Great Lakes cost sheets but represent the best information available under the circumstances.

To illustrate both the changes in costs and the economies of scale involved with changing vessel sizes, four ocean vessels will be examined: 55,000; 100,000; 250,000 and 365,000 tons. Of these, only the first two sizes actually travel to the U.S. hauling ore either to the gulf or to east cost ports. The draught requirements for the other two vessels are too large. Indeed, the maximum draught for U.S. ports limits ship size to about 100,000 tons while the worldwide maximum, typically, is 150,000 tons. The larger ore carriers are exceptions.

The discussion here follows the pattern of the last chapter. First the technical assumptions will be stated, then the cost elements valued and finally the results presented.

Technical Assumptions

The technical values came from private sources and the published literature. A typical route, as a foreign source indicates, is from Tubarão, Brazil to Burnside, near Baton Rouge. The distance is about 5,600 statute miles. The unloading rate at this port is given as 625 long tons per hour. The speed of a 55,000 tonner is about 17 miles per hour.

Another source at Maritime Administration indicates that 340 days is an appropriate season, though estimates differ somewhat. Maritime Administration also indicates that a typical consumption rate at sea for such a vessel is about 13,000 gallons per day.[77] The fuel consumption rate for the larger vessel (100,000 tons) is a literature value estimate.[78] The unloading rate for such a vessel is assumed to be slightly higher and is set at 1000 lt/hr.[79] Loading rates for both vessels are assumed to be the same at 5,000/lt per hour, slightly less than a thousand footer on the Great Lakes. The speed for the larger vessel is also assumed to be somewhat higher and is equal to about 18 miles per hour.[80]

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[77] Caponitti, Steve; Maritime Administration; Washington, D.C.; personal communication.

[78] Drewry's Shipping Consultants, Ltd.; Shipping Statistics and Economics; (September, 1987) p. XXXVII. See the Mega Star, for example.

[79] Lloyd's Ports of the World (London, England, 1981); see "Baton Rouge".

[80] Maritime Administration; Bulk Carriers in the World Fleet; U.S. Department of Transportation, Office of Trade Studies and Statistics; Washington, D.C.; (January 1, 1981). Among other technical information that publication lists speeds of vessels of various

Frankel indicates the following typical foreign dry bulk carrier prices for 1980: \$14.20 million for 20,000 DWT; \$26.88 million for a 50,000 DWT; and \$45.80 million for a 100,000 DWT.[81] Elsewhere, his prices indicate a steady increase from 1977-1980 but decreases occur in \$/DWT with increasing DWT.[82] Drewry's gives a price of between \$16-17 million for a new 65,000 tonner (bulker); elsewhere the price for two Panamax dry bulkers is given as \$18 million. Second-hand sales, however, vary considerably mainly as a function of ship age. Thus a fairly new 1984 vessel of 37,080 DWT may sell for \$9.51 million while a 1972 vessel of 253,994 DWT may go for only \$8.60 million and a 1969 vessel of 106,850 DWT may sell for \$3.92 million.[83] Based on Drewry's report on new vessel prices, a 55,000 tonner would presently (1987) cost about \$14 million and a new 250,000 tonner would cost about \$49 million. The costs of 100,000 and 365,000 tonners were interpolated from these data to be \$23.5 and \$56.7 respectively.

Neither vessel is a self-unloader and so the fuel consumption in part is a function only of the generators run for ships services. For the 55,000 ton vessel the generator consumption rate is taken to be that of a Great Lakes ship, 350 gallons/day. For the 100,000 tonner this is increased to 500 gallons/day.

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tonnages including those of the Brazilian fleet. See pp. 006-007.

81 Frankel, op. cit., p. 184.

82 Ibid., p. 160.

83 Drewry's Shipping Consultants, Ltd., op. cit., pp. 37, XXXVII.

Cost Elements

The ocean market is very different from that of the Great Lakes. It is much more volatile and harder to generalize about certain costs, especially the construction costs paid. While new ships are available, American shippers of iron ore contracting from Brazil to the U.S. are likely to purchase second-hand vessels for additional shipping needs which are considerably cheaper. However, second-hand vessels will likely have higher maintenance and repair costs and a shorter service time. Even a new vessel has a shorter service time on the oceans than on the lakes. Typically it will last 15-16 years, and 18 years at the most.

The financing arrangements also vary considerably depending on market conditions and the country from which the vessel is purchased. It is common to pay 20% down and finance the rest for a period of eight, not 20-25 years. The rate of interest also varies. One source indicates that Korea has offered vessels as low as 4% interest per annum. Assuming purchases are made under the most favourable conditions to the buyer, the figures of 20% down and 4% rate of interest are retained here.

Wages, too, can differ significantly if a foreign crew is used. While the Great Lakes vessels must use American crews for their trade, and while Canada uses Canadian crews, American shippers engaging in foreign trade may use foreign crews and the savings in wages can be substantial. Instead of paying $247/man/day as on the Great Lakes American vessels, a Brazilian crew may rate only $56/man/day or a

Korean crew only $44/man/day. In these cost sheets a wage rate of $56/man/day average is assumed for all vessels.[84]

Crew sizes are not as variable. One source indicates that normally crews range from 22-24 but certainly reach no more than 28. Another source claims that both lakers and ocean vessels have the same sizes of crews (27, 28, 29) and the same wage rates, unions, and horsepower (assuming an American crew). A thousand footer on the Lakes is close to a Panamax (50,000-70,000 tons) flying the American flag. Here the crew size is assumed to be 25 for a 55,000 ton ore carrier as indicated by a source at Maritime Administration and is increased to 28 for a 100,000 ton carrier.

Stores and supplies, maintenance/repair and insurance are derived from data in the DRI study.[85] For the 55,000 ton ore carrier these values are: $252, $1,166 and $1,365. For the larger carrier they are $376, $1,514 and $1,585.

The towing and pilotage fees are taken from a study by Booz, Allen and Hamilton and are the same for all vessels. These are: .05 cents/lt and .03 cents/lt respectively.[86]

A private shipping source indicates that the value for port changes is .40 cents/lt and this value is used for all cost sheets.

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[84] Caponitti, Steve; Maritime Administration; Washington, D.C.; personal communication. See Also, Canadian Transport Commission, Working Paper: Crew Costs and Their Impact on Employment; 1984, p. 22. The 1984 (U.S. $) wages exclude some features and so understate the wage rate. Compare p. 18 where the data indicate the wage rate may be closer to $67/man/day under a Liberian flag.

[85] Data Resources, Inc., op. cit., p. B-30.

[86] Booz, et. al., op. cit., p. 23.

The overhead is calculated as with Great Lakes vessels and is 12% of the operating costs. The miscellaneous category "other" is valued at $107 and $147 respectively for the two vessels and is likewise derived from the DRI study.[87]

There are no winter lay-up fees, user fees or tolls.

Results

The results of these different cost items yield a one way trip cost/ton of $5.42 and $4.21 for the 55,000 ton and 100,000 ton vessels respectively. Round trip, the results are $10.84 and $8.43 respectively. (See Exhibits 5 and 6.) The measures of technical efficiency are 1,711 and 2,103 tons-miles/gallon respectively. In both of these measures the economies of scale are seen. Larger vessels deliver ore per ton more efficiently both in terms of dollars and energy.

One private source indicates that the spread of dollar values presently paid for ore ranges from $3.95/lt to $5.50/lt. The lower figure is more representative of the present value and is contracted for three years from an European source at that price. Another private source indicates that $5.00/lt is an approximate price presently paid. The results of this analysis come close to these figures only on the one way results ($5.42, $4.21) which is valid if the backhaul carries cargo, not ballast.

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87 Data Resources, Inc., op. cit., p. B-30.

Exhibit 5

TUBARAO COST SHEET

TECHNICAL ASPECTS:

Vessel Class OC:	OCEAN	**Loading rate:**	5,000
Tonnage:	55,000	**Unloading rate:**	625
Speed:	17.25	DFC **in port:** 350	0
Distance:	5,642.00	DFC **at sea:**	13,306
Voyage Days:	17.84	**Days in port:**	4.21
Season (days):	340	**Engine type:**	**Steam**

					DAILY	TRIP
AMORTIZATION & INTEREST:			1,663,512 /yr		5,922	105,629
Constr.$:	Int.:	Years:				
11,200,000	0.04	8				
2,800,000 20% DOWN						
OPERATING COSTS:						
FUEL($/G):	at sea:	0.36 /.58			4,993	68,047
	in port:	0.58			203	854
WAGES:	avg/man:	56			1,400	24,971
	crew #:	25				
STORES/SUPPLIES:					252	4,495
MAINT/REPAIR:					1,166	20,797
INSURANCE:					1,365	24,347
LAY-UP:	Annual $:	0			0	0
TOWING:					0.05 /LT	2,750
PILOTAGE:					0.03 /LT	1,650
PORT CHARGES:					0.40 /LT	22,000
OTHER:					107	1,908
OVERHEAD (12% OF OC):					1,138	20,618
TOLLS:						

TOTAL COST:	**$298,066**	**One Way**
COST /TON:	**$5.42**	**One Way**
	$10.84	**Round Trip**
TON-MILES/GALLON:	1,711	**Either Way**

Exhibit 6

TUBARAO COST SHEET

TECHNICAL ASPECTS:

Vessel Class OC:	OCEAN	Loading rate:		5,000
Tonnage:	100,000	Unloading rate:		1,000
Speed:	18.40	DFC in port:	500	0
Distance:	5,642.00	DFC at sea:		21,000
Voyage Days:	17.78	Days in port:		5.00
Season (days):	340	Engine type:		Diesel

				DAILY		TRIP
AMORTIZATION & INTEREST:		2,376,445	/yr	8,460		150,390
Constr.$:	Int.:	Years:				
16,000,000	0.04	8				
4,000,000 20%DOWN						
OPERATING COSTS:						
FUEL($/G):	at sea:	0.36	/.58	7,850		100,294
	in port:	0.58		290		1,450
WAGES:	avg/man:	56		1,568		27,873
	crew #:	28				
STORES/SUPPLIES:				376		6,684
MAINT/REPAIR:				1,514		26,913
INSURANCE:				1,585		28,175
LAY-UP:	Annual $:	0		0		0
TOWING:				0.05	/LT	5,000
PILOTAGE:				0.03	/LT	3,000
PORT CHARGES:				0.40	/LT	40,000
OTHER:				147		2,613
OVERHEAD (12% OF OC):				1,600		29,040
TOLLS:						

TOTAL COST:	$421,432	One Way
COST /TON:	$4.21	One Way
	$8.43	Round Trip
TON-MILES/GALLON:	2,103	Either Way

Other Vessels

Two other vessels that are examined are capable of hauling 250,000 and 365,000 long tons of iron ore. While these ships do not traffic with the U.S., they do illustrate the relative cost and energy reductions, the economies of scale, that are achieved in shipping today.

The source for the cost values used here are the same as these cited above for the two "smaller" vessels but with the following exceptions. The construction cost for the 365,000 ton ship is regressed from the data found in the DRI study and is probably too large. For both vessels the generator fuel consumption rate is set to 900 gallons per day. The consumption rate for the main propulsion plant is regressed from other data to be 43,320 gallons per day. For the 250,000 ton ship, and its unloading system fuel consumption rate, similarly regressed, is 3,150 gallons per day. For the larger vessel the main propulsion plant consumes 54,516 gallons per day, a figure regressed from DRI data as is the unloading system fuel consumption rate of 3,990 gallons per day. Both vessels use the same loading and unloading rates of 16,000 and 10,000 lt/hr., respectively. Likewise the speed for both vessels is assumed to be about 18 miles per hour.

These very large vessels can, not surprisingly, deliver a ton of iron ore at comparatively low costs. Thus the 250,000 ton vessel results in $6.35/lt and an energy efficiency of 2,548 while the 365,000 ton ship delivers a ton of iron ore for $5.28 and has an energy efficiency of 2,957. (See Exhibits 7 and 8.)

In the next chapter these values will be compared with those of the Great Lakes vessels.

Exhibit 7

TUBARAO COST SHEET

TECHNICAL ASPECTS:

Vessel Class OC:	OCEAN	Loading rate:	16,000
Tonnage:	250,000	Unloading rate:	10,000
Speed:	18.40	DFC in port: 900	3,150
Distance:	5,642.00	DFC at sea:	43,320
Voyage Days:	14.55	Days in port:	1.78
Season (days):	340	Engine type:	Steam

				DAILY	TRIP
AMORTIZATION & INTEREST:		5,792,585 /yr		20,622	300,092
Constr.$:	Int.:	Years:			
39,000,000	0.04	8			
9,750,000	20% DOWN				
OPERATING COSTS:					
FUEL($/G):	at sea	0.36	/.58	16,117	205,918
	in port	0.58		2,349	2,830
WAGES:	avg/man:	56		1,568	22,818
	crew #:	28			
STORES/SUPPLIES:				809	11,773
MAINT/REPAIR:				2,797	40,703
INSURANCE:				2,377	34,591
LAY-UP:	Annual $	0		0	0
TOWING:				0.05 /LT	12,500
PILOTAGE:				0.03 /LT	7,500
PORT CHARGES:				0.40 /LT	100,000
OTHER:				147	2,139
OVERHEAD (12% OF OC):				3,140	52,893
TOLLS:					

TOTAL COST: $	793,756	One Way
COST /TON:	$3.18	One Way
	$6.35	Round Trip
TON-MILE/GALLON:	2,548	Either Way

Exhibit 8

TUBARAO COST SHEET

TECHNICAL ASPECTS:

Vessel Class OC:	OCEAN	Loading rate:	16,000
Tonnage:	365,000	Unloading rate:	10,000
Speed:	18.40	DFC in port: 900	3,990
Distance:	5,642.00	DFC at sea:	54,516
Voyage Days:	15.33	Days in port:	2.55
Season (days):	340	Engine type:	Steam

				DAILY	TRIP
AMORTIZATION & INTEREST:		6,737,222	/yr	23,984	367,705
Constr.$:	Int.:	Years:			
45,360,000	0.04	8			
11,340,000	20% DOWN				
OPERATING COSTS:					
FUEL($/G):	at sea	0.36	/.58	20,148	257,413
	in port	0.58		2,836	4,853
WAGES:	avg/man:	56		1,568	24,039
	crew #:	28			
STORES/SUPPLIES:				1,140	17,477
MAINT/REPAIR:				1,800	27,596
INSURANCE:				1,470	22,537
LAY-UP:	Annual $	0		0	0
TOWING:				0.05 /LT	18,250
PILOTAGE:				0.03 /LT	10,950
PORT CHARGES:				0.40 /LT	146,000
OTHER:				147	2,254
OVERHEAD (12% OF OC):				3,493	63,764
TOLLS:					

TOTAL COST:	$ 962,838	One Way
COST /TON:	$2.64	One Way
	$5.28	Round Trip
TON-MILE/GALLON:	2,957	Either Way

CHAPTER VII

RESULTS AND COMPARISONS

The following chapter highlights and compares the results of the foregoing cost analysis and illustrates the utility of the cost sheet for dealing with certain policy issues. These issues include the Jones Act, Public Law 99-662 and tax policies faced by the iron ore industry.

Comparison of Results

The results of the cost analysis confirm the belief that significant cost reductions occur in the shipping industry with increasing vessel size. The economies of scale achieve both a greater economic and a greater energy efficiency. These cost changes can be summarized and compared in the following table:

Table VI

LAKE COSTS

Class	Cost/ton	Tonnage	Ton-miles/gallon
VC-10	$3.74	69,712	2,091
VC- 7	5.14	30,512	1,373
VC-5	6.64	18,855	848

Clearly, as the tonnage decreases from nearly 70,000 DWT to 19,000 DWT, the cost increases from $3.74 to $6.64/ton. Similarly, the energy efficiency decreases from 2,091 ton-miles/gallon to only 848 ton-miles/gallon for the smallest vessel. This represents a 178% increase in cost and a 59% decrease in energy efficiency.

The same trend is seen in the comparison of ocean vessel costs:

Table VII

OCEAN COSTS

Class	Cost/ton	Tonnage	Ton-miles/gallon
OC-36	$ 5.28	365,000	2,957
OC-25	6.35	250,000	2,548
OC-10	8.43	100,000	2,103
OC-05	10.84	55,000	1,711

Note that the 100,000 ton vessel achieves about the same energy efficiency as a Great Lakes thousand footer: 2,103 compared to 2,091 ton-miles/gallon. However, the 55,000 ton ocean vessel achieves a somewhat higher energy efficiency than the Great Lakes Seaway sized 730 footer which carries 30,512 tons approximately. In other words, the ocean vessel tonnage is in between that of the Seaway sized vessel and the thousand footer and so is its energy efficiency, as one would expect.

The cost differences between the ocean and the Great Lakes vessels reflect the stronger influence of the larger distances traveled by the ocean ships. Thus, the most energy efficient ocean vessel (365,000 tons) could not achieve the cost of a thousand footer: $5.28 compared to the Great Lakes cost of $3.74 per ton. This occurs, also, despite the lower crew wages and the lower financing cost.

The Jones Act

The Jones Act refers to the Merchant Marine Act of 1920. It is section 27 of the Act that is especially important requiring that domestic waterborne, or coastwise, trade be conducted in ships that are built and documented under the U.S. laws, and owned by U.S. citizens.

Two main reasons given to justify the Jones Act are the growth of commerce and the national security. Clinton Whitehurst, Jr. believes that it may help national security, but it has not helped the growth of commerce. By giving domestic shipbuilders a monopoly on domestic trade, competition is reduced or eliminated and capital costs for ship construction are raised to the detriment of commercial growth.[88]

Since the Jones Act requires the construction of ships engaged in American domestic trade to be constructed in the U.S., the question arises whether and to what extent such a policy raises costs. Whitehurst believes that the advantages and disadvantages of the Jones Act probably balance each other and that the effect on the consumer

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[88] Whitehurst, Jr., Clinton H.; American Domestic Shipping in American Ships; American Enterprise Institute for Public Policy Research; Washington, D.C. and London (1985); pp. 24-28.

price index from elimination of the act would be minimal.[89] Would this conclusion hold true for just the Great Lakes trade in iron ore?

Clearly, the answer depends on what the alternative construction costs are in other countries. The General Accounting office, in a recent study, found that for building 730 foot vessels in the U.S. and Canada, using 1980 U.S. dollars, the construction cost difference was negligible: \$24.6 million in Canada versus \$25.9 million dollars in the U.S.[90] Another study found that Canadian costs for a lake self-unloader in 1983 was about \$36 million dollars.[91] A private study, however, recently compared Canadian and Korean costs and found that for a Seaway sized vessel the Canadian cost would be \$44.0 million while the Koreans could construct such a vessel for \$34.0 million.[92] Would this make any significant difference in the final round trip cost per ton?

Using the present cost sheets and holding all other factors constant, the following results are obtained. With the 44 million dollar construction cost the round trip cost per ton would be \$6.35. At \$34 million dollars construction cost the cost per ton would be \$5.49. If a 730 feet vessel were built in the U.S., taking the Canadian figure of \$44 million as an approximate U.S. value, instead of in Korea, the difference in cost per ton would be \$0.86.

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89 Whitehurst, Jr., op. cit., p. 28.

90 General Accounting Office, op. cit., p. 34.

91 Yec and Cobugkill: Preliminary Analysis of Carrier Costs; Toronto, Ontario; 1985; p. 6-5.

92 Touche Ross and Co., op. cit., p. 22.

A similar analysis can be done with respect to crew wage rates. What effect would the use of foreign crews have on domestic shipping rates? One study indicates a Canadian wage rate for a Seaway sized self-unloader to be $163 average/man/day.[93] Using this rate along with the Brazilian crew wage rate used for the ocean analysis, the round trip costs per ton compared to present U.S. costs are:

Table VIII-A

WAGE CHANGES

Class	Nationality	Wages	Crew Size	Cost/ton
730	Canadian	$163	28	$4.74
730	Brazilian	56	27	4.11
730	American	241	27	5.14

At the Canadian wage rate of $163, the cost per ton is $4.74. With a foreign, i.e., Brazilian wage rate of $56, the round trip cost per ton is $4.11 and these are compared with the American wage rate giving a cost per ton of $5.14. At the Canadian rate the cost is $.40 less than at the U.S. rate. At the Brazilian rate, the cost is $1.03 less than for the U.S. These differences in average wages do make substantial differences in the final cost per ton.

These cost differences would be significant if most of the U.S. ore moved in vessels of that size. Instead, they move mainly in

93 Canadian Transport Commission, op. cit., p. 19.

thousand footers. If the same wage rates were to apply to vessels of this larger class, the following cost differences would result:

Table VIII-B

WAGE CHANGES

Class	Nationality	Wages	Crew Size	Cost/ton
1000	Canadian	$163	30	$3.48
1000	Brazilian	56	30	3.15
1000	American	247	30	3.74

At the Canadian wage rate, the cost per ton is $3.48 which is $.26 less per ton. With the Brazilian rate the cost is $3.15 which is $.59 less per ton than the U.S. cost of $3.74. Again these represent substantial cost differences resulting from the restrictions of the Jones Act.

Presently there is a trade package on the table between Canada and the U.S. Among other things this package has policies or agreements that would effectively eliminate the Jones Act, allowing Canadians to engage in American domestic (coastwise) trade for any new arrangement (e.g., the institution of a new route, new commodity, etc.). This worries American shippers because the Canadians have lower wage rates and their capital costs are lower since their shipping industry is more heavily subsidized than the U.S. shipping counterpart. (Mexico, having most favored nation status, might also be able to engage in such trade.)[94] The exact outcome of such an arrangement, however, remains yet to be seen.

Seaway Costs

In 1982 the interest and the principal on the Seaway debt were forgiven.[95]

In April of 1987 the tolls on the Seaway were eliminated on the American side. This is part of the new law called the Water Resources Development Act of 1986. Now only Canadian tolls are left and this law authorizes and instructs the Secretary to pursue talks with the Canadians after two years to the effect of persuading them to drop their tolls. Individual shippers still pay a toll but these are then rebated from the Treasury.

From the same law a user fee has now been established in an effort to pay for regular maintenance and operations (m & o) as well as to pay for new construction. The user fee breaks down into two categories: (1) an ad valorem cargo charge is levied either for cargo unloading or loading but not both which is handled by the Harbor Maintenance Trust Fund (and applies both to imports and exports). This is a uniform charge of .04%/dollar of cargo value. This covers m & o. And (2) new construction is covered for drafts of 20 to 45 feet depth in this way: 25% of the cost must be paid "up front", that is, over the construction period of four years; 10% is to be paid over the "life" of the project

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94 Thorp, Steven, Great Lakes Task Force; personal communication.

95 Ibid.

not to exceed 30 years. This means that 35% of the cost is to be covered by non-federal entities and the rest is to be covered by the Federal government. But the law makes no provision how this cost is to be distributed or paid for by these non-federal entities.

Examples of new constructions might include: the newly authorized lock at the Soo (though there are no immediate plans or intentions of construction); new deepening or widening, though this is arguably m & o, too.

Rent-Seeking

Modern principles of economic thought include theories not only of how the market should work theoretically but also the structure of incentives explaining why under certain circumstances it might not work. There is always a tendency to protect what is one's own and to seek to change public policy for personal benefit. This concept is referred to as "rent-seeking" and the tendency can be identified in the shipping of iron ore, also.

For example, the Lake Carrier's Association argues that foreign steel is the cause of the steel industry's five year slump and that the voluntary restraint agreements have not worked. Instead, mandatory restrictions on the import of steel are required in order to protect the American steel industry.[96] That the American steel industry is in trouble because its costs have been too high compared to foreign steelmakers is not mentioned as a major reason for the five year slump.

96 Ryan, George J., op. cit., p. 53, 55.

Another author writes in a similar vein. He describes Reagan's Council of Economic Advisors' report on the trade imbalance as a "horror fiction":

> In condescending tone, it implies that American industry must learn to be more competitive, the trade deficit is not as bad as it looks and, if there is a problem, it isn't the government's fault.[97]

Furthermore, contrary to this study, it claims that the Great Lakes fleet is quite efficient. Because 30 vessels have been scrapped since 1982, the author concludes: "What remains is the most productive, most efficient fleet in our history."[98]

The recently formed Maritime American Council (MAC) takes a similar view with respect to shipping and the whole condition of the American merchant marine. When analyzing why the industry is in trouble, no mention is made of using newer technology or of lowering wages or any other cost-reducing remedy. The reason given is that the industry is "so highly fragmented and too often at crosspurposes within itself." Among other things the author claims that increasing dependence on foreign shipping and shipbuilding account for the withering of the U.S. merchant marine. MAC's goals range "from legal challenges to maritime law violations to a congressional awareness

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97 Thompson, op. cit., p. 33.

98 Ibid., p. 35.

program to investigations of U.S. funds spent on foreign ships and shipbuilding."[99]

The policy strategy outlined by the Great Lakes Commission's Economic Analysis and Policy Task Force also identifies foreign imports as one of the key causes for the decline in U.S. steel production. It recommends, among other things, that research and investment assistance be given to the steel industry and that the VRA's be strengthened and maintained.[100]

On the other hand, the Congressional Budget Office study on "How Federal Policies Affect the Steel Industry" claims:

> Trade policy has not. . .had as pronounced an effect on the domestic steel industry as is commonly supposed. The primary reason why protective programs fail is that they do little to increase the profitability of cost-reducing investments. . . .Neither can protection be expected to produce new technologies that overcome the sources of the industry's cost disadvantage. Moreover, by limiting competition, protection may reduce firms' incentives to make new and potentially risky capital expenditures.[101]

But as indicated earlier the steel industry has recently made attempts to cut costs and become more competitive. The set of

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99 Anonymous; "Council Formed to Restore U.S.-Flag Merchant Marine" in Seaway Review, Vol. 16, No. 1 (January - March, 1987): 66.

100 Economic Analysis and Policy Task Force of the Great Lakes Commission; Policy Options to Develop a Strategy to Enhance the Competitive Position of the Steel Industry; November 3, 1986.

101 Congressional Budget Office; How Federal Policies Affect the Steel Industry; February, 1987; p. 36.

incentives is mixed and the rhetoric at one level differs from the actual perception of what needs to be done to improve the industry.

The Poe Lock as a Policy Problem

The Corps of Engineers has recommended and Congress has authorized the construction of a new lock similar in dimensions to that of the now existing Poe lock which is the only one of the Soo locks capable of accommodating the new 1000 footers. The new lock is needed because of the belief that traffic will increase in the future there and because any shut-down of the Poe lock would seriously affect traffic flow from the upper to the lower lakes and would stop all supercarrier movement there.[102]

The estimated cost of the new lock is about 230 million dollars and could presumably be paid using the current method outline in P.L. 99-662 (The Water Resources Development Act of 1986), i.e., using user fees and sharing the cost between federal and non-federal entities.

However, policy problems arise from the lack of specifying how the non-federal share of the construction cost for the new lock at the Soo or anything else are to be distributed. Non-federal entities could be states, cities, or ports as well as one foreign country, Canada, or an interstate agency. The Great Lakes states are on record as supporting the construction of a new lock but only with full federal funding. The argument for full federal funding is based in part on the belief that: (1) the requirement of the non-federal share is inequitable compared to

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[102] Lake Carriers Association, Annual Report, 1986; p. 31.

inland projects; (2) the Soo locks are important nationally both in terms of the economic and defense; and (3) the fees necessarily imposed on Soo traffic based on PL 99-662 appear to be inconsistent with the intent of Congress to do away with all Seaway tolls.[103]

The Cost Sheet as a Policy Tool

If the St. Mary's River requiring dredging presently prevents ships from using their entire capacity, there is a loss of economies of scale raising the cost per ton of iron ore. The cost sheet can be used there to estimate the benefit in terms of money saved or reduced cost per ton of a dredging project to deepen relevant portions of the St. Mary's River. The Army Corps of Engineers estimates that such dredging would cost 3 million dollars.[104] How does the too narrow river increase costs now? Since it is presently too shallow ships cannot load to their maximum capacity and thereby exploit their economies of scale. For example, if we look at the seven largest thousand footers and calculate their current cost/ton and compare that cost with the cost/ton that would obtain if they could carry a larger but average load, we can estimate the savings per ton that will arise with a deeper channel.

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[103] Thorp, Steven (Great Lakes Commission memorandum): "Cost Share Issues for New Lock at Sault Ste. Marie"; June 25, 1987; p. 2, 3.

[104] U.S. Army Corps of Engineers (Detroit District); Great Lakes Connecting Channels and Harbors; April, 1987; pp. 4, 5 and cost recovery chart (no page number given): Cost Recovery for Duluth, Superior, and Upper St. Mary's River.

Typically these ships carry a maximum of about 64,000 long tons when in fact they could carry around 70,000 or the average for all thousand footers which is used here, 69,712 long tons. At the lower carrying capacity the cost per ton is $4.00 while at the average capacity the cost/ton is $3.74. This means that each of the 64,000 tons costs 26 cents more than it otherwise would. For one ship this totals to 16,640 dollars. For all seven ships making 40 trips a year this amounts to an extra cost of 4,659,200 dollars, more than enough to pay for the dredging within a year's time. If each of these seven largest vessels could regularly carry the fleet average of 69,712 long tons, an additional 1.6 million tons a year could be brought down at a cost of $5.98 million dollars. This calculation doesn't consider all of the iron ore ships that travel, nor does it consider coal or grain transport but it does show the utility of the cost sheet as a policy tool in cost/benefit analysis.

Posted Prices

One of the purposes of this research was to develop a model of costs that would be independent of the posted prices for the cost of shipping iron ore. There are four main routes for which prices are listed. These are: (A) Head of lakes to lower lakes ports; (B) Marquette to lower lakes; (C) Escanaba to Detroit and Lake Erie; and (D) Escanaba to Lake Michigan ports.[105] Below are the posted prices compared to the estimated costs from this research model:

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105 Anonymous; "Rail and Lake Freight Rates on Iron Ore and Pellets per Gross Ton," in Skillings Mining Review, Vol. 75, No. 4 (January 25, 1986): 19.

Table IX-A

PRICES vs COSTS

Route	Posted Prices	Estimated Costs	% of Cost
A	$7.41	$3.74	198
B	$6.11	$2.97	206
C	$5.64	$2.48	227
D	$4.45	$1.92	232

Clearly, the posted prices are far out of line with the actual estimated costs.

Since these cost estimates were derived Interlake Steamship company has announced new vessel freight rates, that is, new posted prices.[106] Using the same routes these are:

Table IX-B

PRICES vs COSTS

Route	Posted Price (less than 1000ft)	Estimated Costs	% of Cost	Posted Price (1000 footers)	% of Cost
A	$5.25	$5.14	102	$4.50	120
B	$4.40	$3.96	111	-----	----
C	$3.95	$3.21	123	$3.40	137
D	$3.00	$2.35	128	$2.70	141

Interlakes posted prices are much closer to the estimated costs than the prevailing posted prices. For a 730 footer the price exceeds the

[106] Anonymous; "Interlake Announces New Iron Ore/Limestone Vessel Freight Rates," in Skillings Mining Review, Vol. 76, No. 46 (November 14, 1987): 20.

cost by only 2% for route A. For the other routes the differences are greater reaching a maximum of 28%. For the thousand footers the prices are closer than before but not as close as for the smaller vessels. Again for route A the difference is smallest: the price exceeds the estimated cost by 20%. The largest differences occurs with route D where price exceeds cost by 41%.

How are posted prices used? Those companies who must hire fleets to haul their iron ore are at least nominally obligated to pay the posted prices which are used as shipping costs. Even those companies that do own their fleets, for tax purposes, find the posted prices useful in other ways, such as taxes and in labor negotiations. For example, the state of Minnesota taxes iron ore companies on the basis of the market value of the iron ore. They start with a lower lakes (Lake Erie) price and subtract out, among other items, the cost of shipping iron ore. With this method it is to the advantage of the iron ore companies to have higher transportation costs so that the remaining taxable amount is as small as possible. The state of Minnesota uses the posted prices as representative of the cost of shipping iron ore. As seen in the above table, however, these prices are significantly higher than the actual costs. (This difference would be much smaller if the new Interlakes posted prices were used.)

Here is a tax example. The state of Minnesota allows \$.725 per ton of iron unit at about 64% Fe per long ton.[107] Then the formula for calculating the lower lakes or Lake Erie value is: \$.725 x 64.00 =

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[107] Kakela, Peter J.; Professor, Michigan State University, personal communication.

$46.40 Lake Erie value/ton. Multiplying this value by the number of tons produced in a year, say 1,500,000 yields: $46.40 x 1,500,000 long tons = $69,600,000. From this value a nonstatutory transportation allowance is deducted. If posted prices are used of $7.41/lt, then we have $46.4-$7.41 = $38.99. Again, multiplying this latter value times the yearly tonnage gives: $38.99 x 1,500,000 tons = $58,485,000. The difference in revenue then is: $69,600,000 - $58,485,000 = $11,115,000.

If actual costs were used this last figure would be: ($46.40-3.74) x 1,500,000 tons = $63,990,000. The difference in taxable income is then $69,600,000 - 63,990,000 = $5,610,000. This represents nearly 6 million dollars of taxable income not accounted for in the taxing system. The actual loss in tax revenue depends on the other deductions and the rate of taxation. If the tax rate is 11% then the actual revenue lost to the state in taxes is: $5,610,000 x .11 = $617,100 for one company in one year.

Companies also have an incentive to represent their costs with posted prices when negotiating with labor unions to argue that their costs are so high they must make cuts in other areas, for example, in union wages or in the number of employees.

Costing Practices

As noted earlier some commentators believe that certain costs are very difficult to determine, such as capital costs, and that there is a serious problem with the definition of terms used by those in the industry concerned about shipping costs.

One objection to the current costing practices is the omission of opportunity costs that arise in the financing of vessel purchases. The "opportunities" that face individuals and a precise definition of them depends upon knowing individual opportunity sets, a very difficult thing at best. The situation becomes more difficult when placed within the context of subjective valuations of non-monetary benefits. Does this mean then that for the purposes of those involved in the shipping industry the problem is hopelessly clouded? Can there be no meaningful definition of cost? This researcher would argue no. The only meaningful definition of cost in the long run for the purposes of shippers and their customers is the straightforward accounting concept of cost. What people in this industry have to be concerned with are those costs which carry with it the force of law. The failure to make a payment on a voluntary market transaction carries some legal threat and such a cost must be covered in the price charged to the customer. Opportunity costs do not fit into this category and for the most part may be ignored.[108] Short run, market variations can be tailored into a

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108 Actually the situation is more complex than this. As Warren Samuels points out there are paradigms of cost other than that of foregone opportunities. One may consider also Pigovian externalities and Smithian real costs of toil and trouble, too. Externalities do not reflect normal, voluntary transactions and may or may not have legal enforcement of certain rights. Even where they do such enforcement often involves very high transactions costs. Smithian real costs have their own problems. For example, the idea that work involves disutility does not account for the case where the worker enjoys his work and so derives utility from it. Such a concept would also fail to serve the purpose of shippers and others in the industry.

cost sheet based on the long run, average cost and so need pose no problem.

Still, different firms may use different terms or different definitions of the same terms when working out a cost sheet using the accounting approach to cost. There are important differences here but these should not be magnified out of proportion. Thus some cost sheets have simply two main categories: fixed and variable costs. Others have three major categories: fixed, variable, and semi-fixed (or semi-variable). Yet often the substantive items listed beneath these broad headings are similar, if not exactly the same, such as: fuel consumption rates; wages; capital costs etc. Of course, the formula and definition of these terms may themselves vary according to the purpose of the user, and so some agreed upon convention might prove convenient when comparisons are made. Still, in many cases, a careful understanding of the terms used often allows easy conversion from one set of terms to another.

CHAPTER VIII

SUMMARY AND FINAL COMMENTS

In the past twenty-five years the Great Lakes fleet has changed significantly. An examination of major fleet characteristics indicates that the shipping firms have moved away from smaller vessels to vessels of larger carrying capacity. At the same time the number of vessels on the Great Lakes has decreased significantly. This means that fewer ships are hauling more of the iron ore on the Lakes. The fact remains, however, that there are far more vessels on the Great Lakes in the bulk carrier and self-unloader fleets than are needed to haul the yearly shipments of ore. This overcapacity is a form of inefficiency.

Shippers have recently come to rely on larger lakes vessels because these achieve significant economies of scale, which reduce the round trip cost per ton. A similar story holds for the ocean vessels. Economies of scale are seen also in the energy efficiency of these larger ships as measured by the ton-miles/gallon.

Certain policy issues were also examined and the utility of the cost sheet illustrated. The Jones Act, Public Law 99-662 and certain tax policies were analyzed in light of their cost effects on cost/ton of iron ore using the cost sheet developed here. Jones Act restrictions with respect to construction and crewing were found to have a significant effect on final cost per ton. The cost savings of expanding the Poe Lock as authorized by PL-99-662 were examined and were not found to be negligible. The differences in posted prices were considered and applied to a state tax model and were found to yield large losses in potential revenue to the state. Finally, a suggestion was made that future cost models continue to use the familiar terms and definitions of cost sheets as being the most meaningful concept of cost for those involved in the industry, foregoing the more specialized concepts of the economist.

The concept of economies of scale, however, raises issues beyond mere questions of economic cost and energy efficiency. There is in this question of economies of scale a problem that I call the technological fallacy of composition. The fallacy of composition is the belief that what is true of the one or the part is necessarily true of the many or the whole. If one football fan stands up in the stadium, he has a better view. But if all fans stand up no one has such an advantage. The fallacy exists when the conclusion is applied to relational or proportional situations but is valid for "autonomous" (linear or additive) cases, that is, where the conclusion is not dependent on a comparison of the part to the whole. (Thus if all parts of a desk are brown, the whole desk is brown. The "browness" of one part of a desk is independent of the other parts. The same can be said in reference to materials of a desk such as steel or wood.)

The problem of the <u>technological</u> fallacy of composition is seen in the case of economies of scale when the object of study is broadened from a particular unit to include the relation of all involved units. In the case of the automobile a driver has an advantage over the horse and buggy in the sense that he can travel faster from one place to another and has an advantage over his slower neighbors. But if everyone possesses a car, then the relevant set of relationships is changed proportionately: people travel faster but they also live farther away. The advantages over distance and over one's neighbor are lost if everyone does it. Of course, for anyone to have a car, a certain infrastructure must exist: the fields of specialization must be expanded to include suppliers of cement and sand, iron and steel, petroleum for oil, gasoline and plastics, engineers and mechanics, etc. If all of this infrastructure were provided for only one or a few car owners, the expense would be enormous. But mass production allows the necessary economies of scale to be achieved, to lower the cost so that most people can afford a car. By its own inner logic, then, the success of achieving the economies of scale dictates that no individual will have an advantage relative to everyone else, even though the absolute speed of travel has increased. By providing the infrastructure necessary for all or most individuals to have a car, the system eliminates the advantages of the car while making it a necessity in order to live effectively in that society. (How much of our capital development follows this pattern is a tantalizing question but one that is too broad to consider here.)

It would seem on the face of it that the same dilemma obtains for Great Lakes shipping. The owner of a large vessel has an advantage (in cost) over the owner of a small vessel because he achieves or exploits certain economies of scale. But as soon as everyone does this, the relative advantage is lost. The situation does not end there, though.

The ship's ability to achieve its economies of scale is in part dependent upon the exploitation of under-used capacity or facilities of the ports (the infrastructure). If port loading facilities are too slow for the "supercarriers" of iron ore, their cost advantage is lost. Indeed, they may even be worse off than the smaller vessels who will spend less time in port. The economies of scale to be achieved here exist relative to the port facilities which must have some resource yet to be exploited that complements the larger vessel. If they do not, there will be little if any advantage, and the hue and cry will be heard that with these larger vessels we must have larger port facilities. But with larger port facilities, which will be built with some margin of excess capacity, vessel owners will again seek to exploit this under-used resource and build their ships to the very limit. The same pattern can be seen with the locks on the Seaway system: ships are built to fill the locks to their maximum; the complaint is heard that larger locks must be built, in which case if there is any unused capacity in the locks, larger vessels will be built to exploit this and to achieve further needed economies of scale.

In other words, expansion (at one point) leads to a process of adoption and adjustment assured by the force of competition until a new economic balance is reached. Attainment of this equilibrium, however, means the original relative advantage is lost, which in turn induces demand for still more expansion (at some other point).

Future researchers need to answer questions this dilemma raises. How far can such a leap-frogging process go? Is there an optimal level of ship/port capacity? What natural, economic and engineering limits, if any, are there? It would seem on the face of things that however large a vessel can be built on the Great Lakes one can be built larger still on the oceans. What implications does this have for the future of Great Lakes commerce?

It would also be interesting to examine the change in the cost of shipping iron ore over time, say, since 1855. What proportion of its income did a typical 19th century family spend on iron ore products and how does that compare with families today?

Research could also be expanded to include a broader concept of cost. What is the cost when the entire fleet of a firm is considered; or when one looks at the whole integrated industry? What is the cost when the system of locks and canals (the Great Lakes/St. Lawrence Seaway System) is included? How do various subsidies for construction and operation affect these costs?

Ultimately, though, these questions involve values or ideology. Costs and benefits, especially when these are expansively defined, include normative views of how resources should be used predicated on visions of social order. The identification of these values and their effect on the economy constitutes a research issue which is, or ought to be, of vital interest to anyone concerned with resource development.

APPENDIX

APPENDIX

SUMMARY OF MAJOR FORMULAE USED

Formulae Used: Technical Aspects

A. Port Days:

The number of days a vessel spends in port is found by means of the loading and unloading rates:

$$\text{Days in port} = \frac{(t/l) + (t/u) + c}{24 \text{ hrs.}} \quad \text{where,}$$

t = tonnage

l = loading rate

u = unloading rate

c = constant for locking and docking time

B. Voyage Days:

The voyage days are determined by speed, distance and port days as follows:

Voyage days = (distance/speed)/24 hrs. + port days.

C. Ton-miles/Gallon:

The ton-miles per gallon figure is found in the following manner:

Ton-miles/gallon = (tonnage)(miles traveled)/total gallons used.

This reduces to:

$$\text{Ton-miles/gallon} = \frac{(\text{tonnage})(\text{speed})(24 \text{ hrs})}{\text{DFC at sea}}$$

D. Other Items:

The remaining items of technical aspects are all input data.

Formulae Used: Costs

A. The Capital Recovery Method:

$$\text{Uniform yearly payment} = \frac{i(1+i)^n\, p}{(1+i)^n - 1}$$

where i = interest rate (annual)
n = number of years of repayment or vessel use expectancy
p = principal of the loan.

B. Fuel Costs:

$$\text{DFC at sea} = DFC_s + DFC_g$$

$$\text{Cost at sea} = DFC_s P_s + DFC_g P_g$$

where DFC_s = daily fuel consumption for main engines
DFC_g = daily fuel consumption for generators
P_s = price of main engine fuel
Pg = price of generator fuel
DFC_c = daily fuel consumption for conveyor system.

$$\text{Cost in port} = \left(DFC_c \cdot \frac{t/u}{24\text{hrs}} + DFC_g \cdot \frac{(t/L + t/u + c)}{24\text{hrs}}\right)$$

C. Wages:

Average wage/man x number of men,

Both average wage/man and the number of men are given as input data.

D. Other Categories:

Other categories are simply input data; these include: stores/supplies; maint./repair; insurance and the miscellaneous category "other". They also include towing, pilotage and port charges (which are given as cost per ton), lay-up fees and lockage fees.

E. Overhead:

Overhead is derived by taking 12% of the summed operating costs.

F. Tolls:

The Montreal and Welland Canal tolls are summed and multiplied by the Gross Registered Tonnage (GRT). Similarly, the cargo tolls are summed and multiplied by the cargo tonnage:

$$\text{Toll} = (M_g + W_g)\ \text{GRT} + (M_c + W_c)\ \text{Tonnage, where}$$

M_g = Montreal fees for GRT

W_g = Welland Canal fees for GRT

M_c = Montreal fees for cargo tonnage

W_c = Welland Canal fees for cargo tonnage

G. User Fees:

User fees are calculated by taking .0004 times the lower lakes value of a ton of iron ore which is taken to be $38 here. This is then multiplied by the number of cargo tons:

User fee = (.0004) (38) (tonnage)

H. Trip Cost:

The trip cost is found by multiplying each daily cost item by the number of voyage days. Exceptions include the port costs which are multiplied by the number of port days; towing, pilotage and port charges are multiplied by the number of tons; overhead is again the sum of operating costs multiplied by 12%. If tolls apply these are finally added on to give the total (one-way) trip costs.

I. Cost/Ton:

The cost per ton is found by dividing the trip cost by the tonnage: trip cost/tonnage = cost/ton one way. Doubling this value yields the cost/ton round trip.

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