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FOURTH COAST-SEAWAY SYSTEMS REQUIREMENTS ANALYSIS VOLUME II

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16. Abstract

This report summarizes the need for an Integrated Marine Traffic Information and Control System (IMTIC) in the St. Lawrence Seaway. The analytic emphasis is on the Welland Canal to Gulf of St. Lawrence portion of the Seaway system. The Upper Great Lakes portion is considered only when interdicting impacts could affect Welland-St. Lawrence subsystem capabilities. An important conclusion is that the total Seaway system and its component elements require immediate and detailed analytical attention if future cargo demands are to be met.

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EXECUTIVE SUMMARY

BACKGROUND

This study was undertaken by the Transportation Systems Center to examine the need for and the benefits of an Integrated Marine Traffic Information and Control System (IMTIC) which has been proposed by the Canadian St. Lawrence Seaway Authority. The study was conducted at the request of the Administrator of the St. Lawrence Seaway Development Corporation with the concurrence of the Under Secretary. The initial purpose of the proposed system was to link together, by an automatic message switching network, all the Seaway entities. Eventually, it will provide an integrated data collection, evaluation and distribution capability leading to improved scheduling for ports, harbors and pilotage, and for control and planning of vessel movements through the Seaway. Geographically, the proposed system would extend from the Gulf of St. Lawrence to the Lake Erie reach (Long Point).

As the study progressed, the interdependencies of trade and cargo movements, traffic patterns and marine operations between the St. Lawrence section and the Upper Great Lakes region led to the conclusion that the proposed system would impact on the entire "Fourth Coast" area. Furthermore, the system should be evaluated in the context of these interdependencies. The study was subsequently expanded to provide an integrated analysis of the entire Seaway system and to determine how IMTIC would affect the system elements. However, limitations of time and manpower constrained the analysis to a determination of trends. It also became apparent that the proposed system would impact not only on the St. Lawrence Seaway Development Corporation, but also on all marine-related entities in the Fourth Coast area, e.g., Maritime Administration, Corps of Engineers, U.S. Coast Guard, National Oceanographic and Atmospheric Administration. Hence a major outgrowth of this study is a proposal to expand IMTIC in geographic coverage and in capability so as to provide the entire Fourth Coast - Seaway with real-time traffic control; cargo, vessel and port scheduling; and coordinated intermodal goods and commodity movements (IMTIC Step 2).

PRINCIPAL FINDINGS

At present there are several traffic control and cargo management programs under the sponsorship of various Federal agencies, e.g.:

- St. Lawrence Seaway Development Corporation: Integrated Marine Traffic and Information Control System
- U.S. Coast Guard: Coast Guard Role in Vessel Traffic Systems

- Maritime Administration: Shipping Operations Information System

- National Oceanographic and Atmospheric Administration: Electronic Positioning System for Vessels in Lake Ontario

Considering the numerous agency involvements in traffic control and management, a principal finding of this study is that all U.S. agencies with responsibility in intermodal marine transportation activities in the Fourth Coast area should expand and further coordinate their maritime research and development programs if the full potential of IMTIC Step 2 is to be realized.

The system service capacity of the St. Lawrence River and Welland Canal sections of the Seaway is expressed as the number of ton-miles of cargo carried per year. Current statistics show that the system service capacity has reached a plateau. Transits have decreased; tonnage per transit has increased. Projections are for transits to stabilize at or slightly above current levels. However, tonnage per transit will increase sharply and system service capacity will have to rise.

System service capability is currently constrained by the system elements. Preliminary findings have indicated:

- Traffic control element cannot meet current sustained loads; and may not meet post-1975 demand.

- Pilotage element (ocean vessels) cannot meet current peak loads.

- Safety is proportional to ton-miles; in peak periods safety margins are significantly degraded, and cannot meet current peak demand.

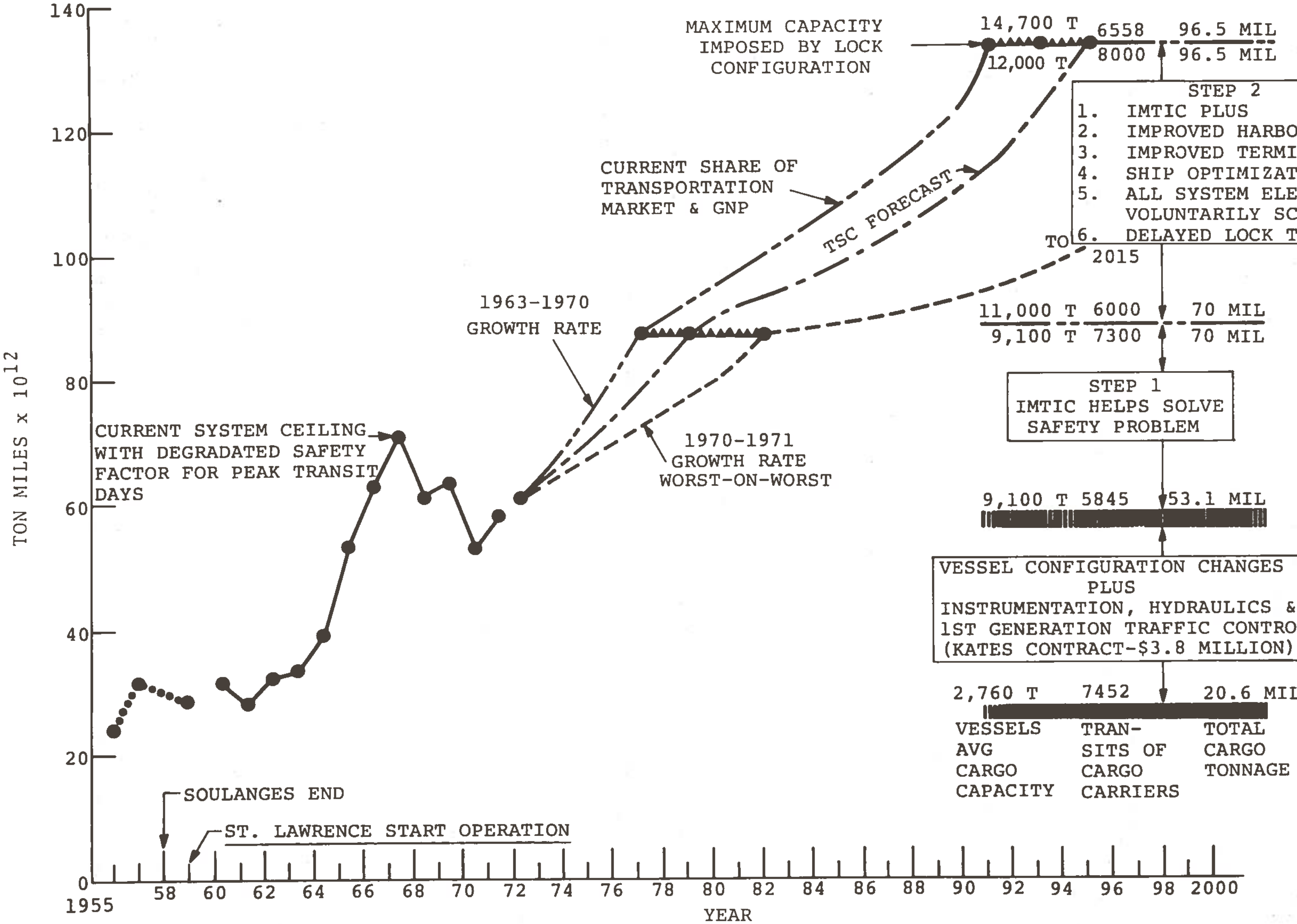
- Ports and harbors element cannot meet current peak general cargo needs; may not meet post-1975 demand.

- All weather operations cannot be accomplished.

- Locks element in the St. Lawrence and Welland sections cannot meet the post-1990 demand.

- Fleet element, both ocean and laker, cannot meet the post-1980 cargo demand.

The Figure below shows graphically the actual and projected system capabilities and the impacts of IMTIC Step 1 and Step 2. IMTIC Step 1 implemented now will increase system capacity by improving the efficiency of the system elements to accommodate the 1980 projected demands. IMTIC Step 1 will help to alleviate the safety problems, improve pilotage scheduling, enhance the capability of the traffic control element by optimizing traffic patterning, provide for inclement weather operations and permit some degree of



Balancing System vs. Market Demand: Actual and Projected for St. Lawrence Section port and harbor intermodal scheduling. The implementation of IMTIC Step 2, plus fleet and facilitization improvements, by 1980 will extend system service capability up to the limits imposed by the locks' configuration. IMTIC Step 2 with voluntary participation by the trade will permit optimized vessel, cargo and port scheduling, and delay facility improvements until the year 2000.

BENEFITS

The benefits to the trade from fully implemented IMTIC Step 1 and Step 2 will principally be improved safety in operations and increased service to the user. Quantified, these benefits are:

- reduction in accidents; currently, accidents cost the shipowner and insurer over $1 million per year. As traffic rises, the accident rate rises. IMTIC should improve the Seaway safety record.
- delays due to weather, pilotage, equipment failure and vessel incidents amounted to nearly $10 million in lost vessel hours in 1971. IMTIC can reduce delays.
- improvements in transit time due to reduction in traffic-caused queues will amount to over $1.3 million in savings of vessel hours with the implementation of IMTIC Step 1. IMTIC can plan a more uniform vessel arrival rate.
- improved utilization of marine facilities and port turnaround times due to intermodal vessel, cargo and port scheduling with IMTIC Step 2 could amount to over $50 million savings annually, plus over $2 million savings due to reduced inventory requirements.

COSTS

The total costs for IMTIC Step 1, providing a capability for near real-time traffic control(phases 1-3) are:

Investment	$1,500,000
Operations and Maintenance	$225,000 per year

Based on a 27-73 percent U.S.-Canadian cost-sharing ratio, the U.S. commitment for the St. Lawrence section would be:

Investment	$300,000
Operations and Maintenance	$30,000 per year

To provide the real-time traffic control capability(phase 4) for IMTIC Step 1, an automated vessel location and identification system is necessary. The total investment cost for this capability has been estimated between $3 to $6 million. The annual operations and maintenance cost for the U.S. portion of the total system has been estimated at $50,000.

No cost estimates have been made for IMTIC Step 2.

RECOMMENDATIONS

- IMTIC Step 1 be implemented immediately as a joint venture between St. Lawrence Seaway Development Corporation and the St. Lawrence Seaway Authority. System is technically feasible; U.S. involvement justifiable on the basis of requirements, costs and benefits.
    - DOT fund investment cost($300K) for phases 1 through 3
    - SLSDC fund recurring costs for all phases ($50K program)
    - DOT fund phase 4 jointly with other concerned agencies
- Using the analysis and results of this study as background, DOT initiate an immediate systems and requirements analysis of traffic control and vessel/cargo information systems for the St. Lawrence River - Great Lakes area.
- DOT should invite other U.S. and Canadian maritime entities to establish an interagency task force which would serve as a coordinating and integrating body for all vessel/cargo control and information system programs in the Great Lakes - St. Lawrence River area. Task Force to be constituted with membership from the following U.S. agencies and their Canadian counterparts.
    - U.S. Army, Corps of Engineers
    - U.S. Coast Guard
    - St. Lawrence Seaway Development Corporation
    - Maritime Administration
    - National Oceanographic and Atmospheric Administration
    - Federal Communications Commission

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF TABLES

1.0 INTRODUCTION

This study was undertaken by the Transportation Systems Center, (TSC), Cambridge, Massachusetts for the St. Lawrence Seaway Development Corporation. It was conducted with the joint assistance of the Corporation and its Canadian counterpart, the St. Lawrence Seaway Authority.

This study considers the impact of traffic planning, vessel control, management information, port planning and scheduling in the area served by the St. Lawrence Seaway. Specifically, the study focusses on the economic and technical feasibility of an Integrated Marine Traffic and Information Control System from Montreal through the Lake Erie reach (IMTIC Step 1). It also briefly examines the expansion of IMTIC Step 1 into the entire Fourth Coast area (IMTIC Step 2). The initial system was proposed by the St. Lawrence Seaway Authority to provide an integrated traffic information, scheduling, vessel location and reporting capability throughout the Montreal to Lake Erie sections. This proposal was subsequently expanded to include from the Gulf of St. Lawrence to the head of the Great Lakes. This study establishes the requirements, benefits, and orderly development of IMTIC Step 1. It also establishes the need for a total systems analysis of IMTIC Step 2.

At the request of the Administrator of the St. Lawrence Seaway Development Corporation and with the concurrence of the Under Secretary, the Transportation Systems Center agreed to undertake this study. The initial role for the Center was to examine the system which has been proposed by the St. Lawrence Seaway Authority and to recommend a United States position with respect to it. As the study progressed, the scope was expanded to include a preliminary analysis of the total Seaway system in sufficient detail so as to indicate trends. The approach which has been used by TSC in this study was to determine if there is a need for this system both now and in the foreseeable future; and if a need does exist, is the system justifiable on the basis of cost, savings and benefits? Implicit in this study is sufficient background data to provide the basis for a technical development plan and for the development of a budgetary submission.

The data base used in this study was supplied principally by the St. Lawrence Seaway Development Corporation and the St. Lawrence Seaway Authority and derived secondarily from contractor reports, regional study commissions and trade journals. The presentation of the data, its emphasis and the conclusions derived are responsibilities of the Transportation Systems Center.

The results and recommendations presented in this study are those of the Transportation Systems Center. This study does not necessarily present a position of the United States Government or the United States Department of Transportation.

2.0 SEAWAY GOALS AND OBJECTIVES

The principal objectives of the St. Lawrence Seaway are three fold:

- Help develop the economic potential of the Great Lakes Area.
- Assist in meeting the needs of the principal economic units served by the Seaway.
- Enhance the utilization of existing public facilities.

To help achieve these goals the St. Lawrence Seaway Development Corporation was chartered by Congress to construct, maintain and operate deep-water navigation works in the St. Lawrence Seaway and to coordinate its activities with those of its Canadian counterpart, the St. Lawrence Seaway Authority.

Developing the economic potential of the Great Lakes area, the St. Lawrence Seaway has linked the mid-continent of North America with the seaports of the world.* The Great Lakes and St. Lawrence River Ports have now achieved a new dimension and have become international seaports. More importantly, the Seaway has created within the heartland of America an additional coastal region capable of competing with the East, West, and Gulf Coast areas. Recently, Congress has acknowledged this fact by designating the Great Lakes Area as the Fourth Coast. The industrial and agricultural potential of the Great Lakes - Seaway region rivals that of any comparable area in the world. Although generally it is the coastal area which is the dominant region of a nation, in North America it is the Great Lakes - St. Lawrence River Area which is the most important sector for population, industrial production, agriculture and employment. This region out produces the six nations of the European Common Market and the entire Soviet Union as well.

Serving this area there are fifty-six ports providing deep water facilities for ocean and lake shipping. Many of these ports are closer to Northern Europe and Great Britain than East Coast ports. The normal great circle sailing distance from Baltimore to Liverpool is 3936 miles. From Detroit to Liverpool via the Seaway the distance is 3700 miles. Cargo shipped from Liverpool to Detroit via Baltimore requires an additional sea distance of 236 miles plus the overland distance of 604 miles to complete the

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*Much of the data in this section was extracted from The Next Decade...1969-1979, St. Lawrence Seaway, by John L. Hazard, Michigan State University, The Great Lakes Commission, Ann Arbor, Michigan.

transit. Additionally, the cargo must be off-loaded at Baltimore and transshipped by rail or truck. Despite the economic potential of the Great Lakes Area for overseas trade through the Seaway, the bulk of the overseas traffic from this region is carried by road and rail to coastal ports and then transshipped overseas. In absolute terms, U.S. lake ports are handling only 3.5 percent of the U.S. overseas waterborne trade and approximately 6 percent of the value. These figures do not include Canadian trade. If the U.S. lake ports were to carry a third of the Mid-North American Trade, they would double their existing traffic or if they were to accommodate a seasonal two-thirds, they would quadruple their present traffic. The economic viability of the Great Lakes Area already exists, however, the role of the Seaway in achieving the full potential of the area has yet to be fulfilled.

The restricted shipping season has been the single most important factor in the Seaway's very low share of the U.S. overseas waterborne trade. More significantly, however, overland trade modes have continued to compete for and retain a massive share of mid-continent commerce by selective rate cutting, and innovative cargo handling and transportation techniques. In the face of this competition, the Seaway and the Lake Port Authorities need to embark on a program leading toward optimum utilization of the Great Lakes - St. Lawrence transportation system. The alternatives are for the system to deteriorate into principally a Laker transshipment route or to continue as a struggling overseas route in a secondary position to the seaboard ports.

In addition to the economic potential of the Great Lakes Area for overseas trade, an equal if not greater potential exists for domestic trade. Some reports have indicated that the real future for the Great Lakes Area depends upon an increased share of domestic traffic[14]. The basis for this appraisal is that the volume of foreign trade traffic predicted to move through the Lakes and Seaway in the near future is insufficient to support the investments required in port and port facilities needed to maintain this level of traffic. From the macro view, the volumes of domestic traffic are far greater than that of foreign trade. If a greater portion of this traffic could be directed to Great Lake-St. Lawrence River Carriers, then the overall investment in ports and facilities could be apportioned over a broader base. This would establish a requirement for services which are now considered marginal or unproductive.

The total U.S. - Canadian investment in the Seaway system has been variously estimated at nearly one billion dollars. Prudent public policy demands a careful stewardship of this investment. The Seaway system represents a valuable international resource to be utilized at its fullest potential. To achieve this goal, the Seaway route should be sufficiently effective to attract an increasingly greater share of waterborne traffic. The total demand for waterborne traffic from the Mid-American region is already high, for the fullest utilization of the Seaway a portion of this demand should be diverted from competing routes.

3.0 ST. LAWRENCE SEAWAY AS A SYSTEM

3.1 INTRODUCTION

The St. Lawrence Seaway represents a water transportation mode consisting of a network of rivers and lakes. Vessel passages on this network are controlled by a series of locks, canals and channels; vessel movements are directed by decentralized traffic control systems. The ocean, lake, coastal and miscellaneous vessels which use the Seaway, the pilots and masters who control the vessels and the lake and river ports which are served by the Seaway all are parts of the system. Impacting on the efficiency of this system are the operational constraints of weather, traffic, accidents, and the administrative constraints of scheduling and inspections. This section considers the elements which constitute the St. Lawrence Seaway system: waterways, ports, fleet, pilotage and traffic control. Subsequent sections consider how these elements are impacted upon, and the role of an improved traffic control and management information system in reducing these impacts.

3.2 WATERWAYS

3.2.1 Lakes, Rivers and Canals (Figure 3-1)

The St. Lawrence Seaway extends from the Gulf of St. Lawrence in the East to the headwaters of Lake Superior in the West, a distance of over 2300 miles. The 189 mile St. Lawrence River Section between Montreal and Lake Ontario contains seven locks that lift a ship 226 feet. Two of the seven locks are maintained and operated by the St. Lawrence Seaway Development Corporation, the remainder by the St. Lawrence Seaway Authority. The two U.S. locks, Eisenhower and Snell, are located in the International Section of the St. Lawrence River near Massena, New York.

3.2.2 Locks

The minimum configuration of all the Welland and Montreal - Lake Ontario section locks is 860 foot length (pintle to pintle) 80 foot width and 30 foot depth. All are filled or emptied by gravity. To raise a vessel, for example, the upstream valves are opened and the water flows into the chamber through openings at the bottom of the walls (See Figure 3-2). To lower a vessel these steps are reversed. It takes less than twelve minutes to raise or lower the water level. Additional time (up to 45 minutes) is required for the vessel to carefully maneuver in and out of the chambers. In the Seaway system, a single lock lift can be anywhere from six inches (Iroquois Lock in the St. Lawrence section) to 45 feet (Snell and Eisenhower Locks). In the Welland section, the Flight Locks* (Locks 4,5 and 6) lift a vessel a total of 139 feet or an average of over 46 feet per lift. The same basic

*Flight Locks share one gate and have the appearance of a flight of stairs

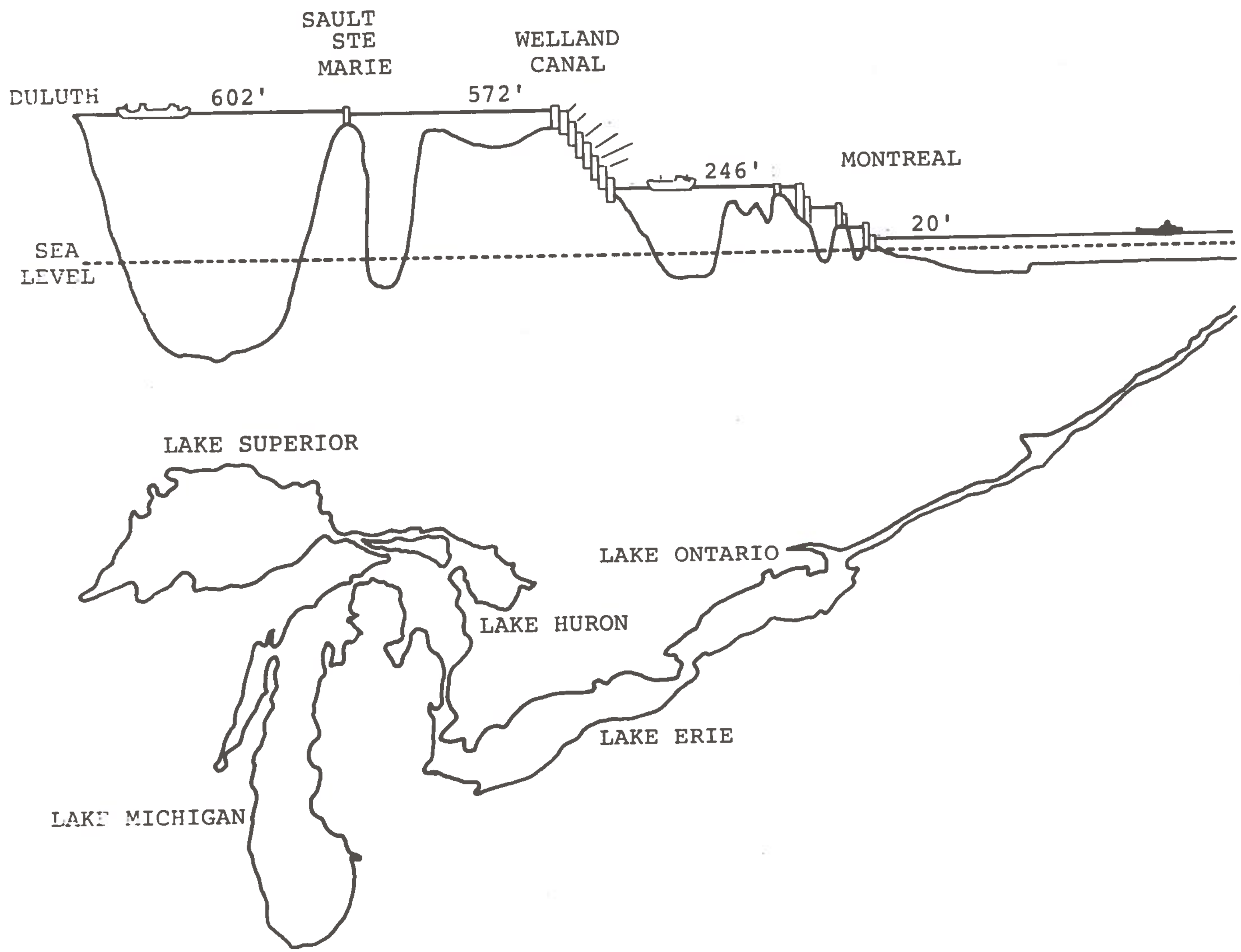


Figure 3-1 St. Lawrence Seaway 2342 Miles Duluth to Atlantic

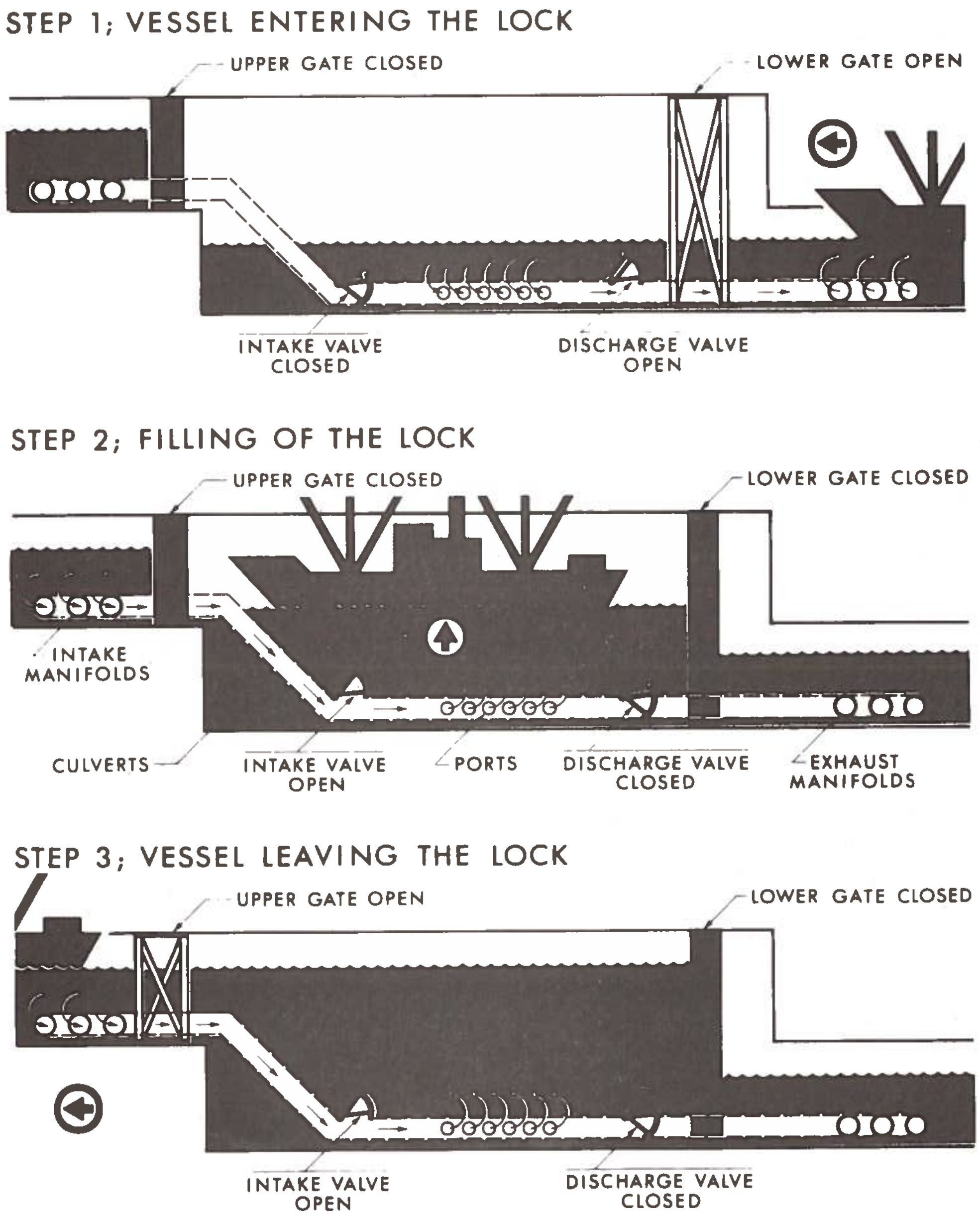


Figure 3-2 Typical Method of Locking a Ship in the St. Lawrence Seaway System

design used in the Panama Canal has been used in the Seaway. The locks are monolithic concrete structures equipped with bull gear driven miter type-gates. However, the Panama Canal uses shore based railed vehicles (mules) to tow the ships through the locks; while in the Seaway the ships provide their own propulsion.

All of the locks in the system are single locks with exception of the flight locks in the Welland Canal. These locks are twinned permitting simultaneous upbound and downbound passage. The U.S. and Canadian governments have initiated economic and engineering system expansion studies for the Welland and Montreal - Lake Ontario sections, but as of now there are no firm implementation plans. The official shipping season for the St. Lawrence River section is from April 1 to December 15, a period of 259 days. Ice is the principal reason for season shut-down, but the shut-down also provides opportunity for facility upkeep and maintenance.

Between Lake Ontario and Lake Erie is the Welland Canal. This section is 27 miles long and contains eight locks that lift a ship 326 feet. It is operated solely by the St. Lawrence Seaway Authority. Ice conditions do not constrain this section as much as the St. Lawrence section; the shipping season often extends into January.

Connecting Lake Erie and Lake Huron is the St. Claire River-Lake St. Claire-Detroit River Waterway. This waterway is a network of rivers plus a two channel system dredged through Lake St. Claire. Although the drop between Lakes Huron and Lake Erie is eight feet no locks are installed in this waterway. The open channel at the Mackinac Straits connects Lakes Huron and Michigan. Both of these lakes are at the same level. Lake Superior is connected to Lake Huron by the St. Mary's River and the locks at Sault Ste. Marie (21 to 23 feet lift). The Sault Ste. Marie consists of five locks, four of which are maintained and operated by the U.S. Army Corps of Engineers, the remaining one, the Canadian lock, by the St. Lawrence Seaway Authority. The Seaway system from the Atlantic to Montreal is constrained to 35 foot draft ships. In the Welland-St. Lawrence section the vessel constraints are 730 foot length, 75.5 foot beam and 26 foot draft. In the Upper Lakes the vessel limits are slightly less than 1000 foot length, 105 foot beam and 27 foot draft.

3.3 PORTS (FIGURE 3-3)

There are 56 St. Lawrence-Great Lakes principal ports which handle lake and ocean traffic; 28 of these ports are U.S. Most of them are tailored to provide fast turn-around service for lake vessels (6-8 hours) carrying bulk cargo. The ocean going vessels carrying general and bulk cargo are rarely so rapidly serviced. Generally, the port turn-around time for these ocean vessels is 3 to 6 days. The typical ocean vessel which enters the Seaway system calls at three to four ports off loading and on loading cargo before returning to salt water. On the other hand, a laker calls at a single port, off loads his bulk cargo, moves in ballast to

1 SEPT-ILES
2 PORT CARTIER
3 BAIE COMEAU
4 MATANE
5 RIMOUSKI
6 RIVIERE-DU-LOUP
7 PORT ALFRED
8 CHICOUTIMI
9 QUEBEC
10 TROIS RIVIERES
11 SOREL
12 CONTRECOEUR
13 MONTREAL
14 CORNWALL
15 MASSENA
16 PRESCOTT
17 OGDENSBURG
18 KINGSTON
19 OSWEGO
20 ROCHESTER
21 BUFFALO
22 OSHAWA
23 * TORONTO
OAKVILLE
PORT CREDIT
LAKEVIEW
24 HAMILTON
25 ERIE
26 ASHTABULA
27 CLEVELAND
28 LORAIN
29 * WELLAND SECTION
ST.CATHARINES
PORT COLBORNE
WELLAND DOCKS
30 SANDUSKY
31 TOLEDO
32 MUNROE
33 WINDSOR
34 DETROIT
35 PORT HURON
36 SARNIA
37 GODERICH
38 OWEN SOUND
39 COLLINGWOOD
40 MIDLAND
41 ALPENA
42 BAY CITY
43 GARY
44 CHICAGO
45 WAUKEGAN
46 KENOSHA
47 MILWAUKEE
48 MUSKEGON
49 GREEN BAY
50 ESCANABA
51 SAULT STE. MARIE
52 MARQUETTE
53 ASHLAND
54 SUPERIOR
55 DULUTH
56 THUNDER BAY

Figure 3-3 St. Lawrence-Great Lakes Main Ports another port in the system, on-loads a complementary cargo and returns.

3.4 GREAT LAKES - SEAWAY FLEET

The users of the Seaway system include tugs and barges, pleasure and military craft, lakes and ocean cargo carriers. Only the ocean and lake vessel traffic is considered since the other users of the system do not seriously contribute tonnage, transits or revenue.

3.4.1 Lake Vessels

According to the Great Lakes Carriers Association, during 1971 there were 417 Canadian-U.S. flag vessels of 1,000 tons capacity or more operating on the Great Lakes and the St. Lawrence River. In addition, there were a few foreign registered lakers, principally Bahamian; most of these do not use the Seaway system. There are 225 U.S.-registered and 162 Canadian-registered lake vessels. Of the Canadian vessels 38 are maximum cargo capacity vessels specifically designed for the Welland-St. Lawrence locks. These vessels are 730 foot length, 75.5 foot beams and 26 foot draft. There are a few larger size ships that are captive within the lakes; these are design constrained by the 1200 foot locks at Sault Ste. Marie. The basic traffic pattern of the laker fleet is shown in Table 3-1. Significantly, the 730 foot vessels account for a large segment of the traffic. Although the U.S. laker fleet is fifty percent larger than the Canadian, less than two percent of the St. Lawrence section laker transits were made by U.S. vessels. Most of these U.S. transits consisted of ore and petroleum traffic. Similarly less than eight percent of the Welland transits were U.S. vessels; most of these were coal and petroleum bulk carriers. Most significant of all is the fact that less than 16 percent of the U.S. lake fleet entered Lake Ontario last year. The balance of the U.S. fleet has mostly been involved in the Upper Great Lakes domestic trade carrying coal, iron ore, limestone and petroleum.

3.4.2 Ocean Vessels

Based on preclearance requests in 1971, 757 ocean vessels entered the St. Lawrence system. These vessels accounted for 2614 transits. Of the vessels that enter the system at Montreal, 86-93 percent transit the St. Lawrence section, cross Lake Ontario and enter Lake Erie; 68-70 percent transit Lake Erie and enter Lake Huron. Lake Superior and Lake Michigan ports receive one-third each of all ocean vessel transits. Most of the ocean vessels carry general cargo although there is a significant portion (over 20 percent) in the bulk cargo trade. The bulk cargo trade consists principally of grains such as wheat, corn and soybeans to Europe and the Far East.

Over forty percent of the ocean transits are made by vessels in the 500-600 foot length class and there appears to be a definite

TABLE 3-1. 1971 TRAFFIC PATTERN - LAKERS OVER 1,000 TONS

REGISTRY	FLEET SIZE	VESSELS	ST. LAWRENCE	WELLAND	ST. CLAIRE	ST. MARY'S
U.S.		0	-	-	DATA UNAVAILABLE	DATA UNAVAILABLE
	255	8	50	57		
		32	-	286		
		40	50	343		
CANADA		7	170	-		
	162	132	2992	3410		
		17	-	769		
		156	3162	4179		
TOTAL	417	196	3212	4522		
BAHAMIAN	2	2		109		
	419	198	3212	4631		
		34	791	1064		
730 Foot Vessels	40	4	-	509		
		38	791	1573		

shift towards the 600-700 foot length. The design constraints for ocean-going Seaway vessels are 709 foot length, 75 foot beam and 27 foot draft. In addition, the maximum capacity is 20,800 tons. The principal constraint for ocean vessels is draft; many of these vessels are forced to off-load some of their cargo at Montreal in order to reduce their draft so as to be accommodated in the locks.

3.5 PILOTAGE (FIGURE 3-4)

All vessels transitting the Seaway are required to have certified pilots on board. This requirement does not impact on the lake vessels since most of the deck officers on these vessels have pilot certificates. However, on ocean and coastal vessels pilots and their availabilities can be a constraint on operations.

There are four pilotage districts: Cornwall, Kingston-District 1, District 2 and 3. The Cornwall district includes the St. Lawrence River from Montreal to Snell Lock in the U.S. sector, District 1 is from Snell Lock to Cape Vincent at the terminus of the St. Lawrence River. District 2 includes the Welland section, nearly all of Lake Ontario and all of Lake Erie to Port Huron. District 3 covers all of the Upper Lakes above Lake Huron. Each of the districts is responsible for its own work assignments and scheduling. The pilots are entrepreneurs in every district except in the Welland Canal portion of District 2. In the latter case they are Canadian government employees.

The scheduling of individual workloads and trip assignments is generally based on a minimum of three 12-hour trips per week, 85-90 trips per year, and an annual gross personal earnings of approximately $27,000. Towards the end of the shipping season, particularly in November and December, these factors can complicate the timely availability of a pilot and can impinge greatly on Seaway system capability.

3.6 TRAFFIC CONTROL

3.6.1 Overview

Traffic on the Seaway is regulated to the extent that Seaway operational rules are enforced (principally by fines), however traffic control is only advisory on the ship's master beyond the immediate vicinity of the locks. Such traffic control as it now exists in the Montreal to Welland Canal portion of the Seaway is polarized about two control centers. In the east, the traffic control center is located at the lock at St. Lambert near Montreal; in the west the center is at St. Catharines near the northern terminus of the Welland Canal. Within the Montreal-Lake Ontario section traffic control is exercised on a manual basis with computer back-up for the maintenance of a data base. In addition, the locks are instrumented with some combination of ultrasonic, microwave or sonar sensors that automatically report and record

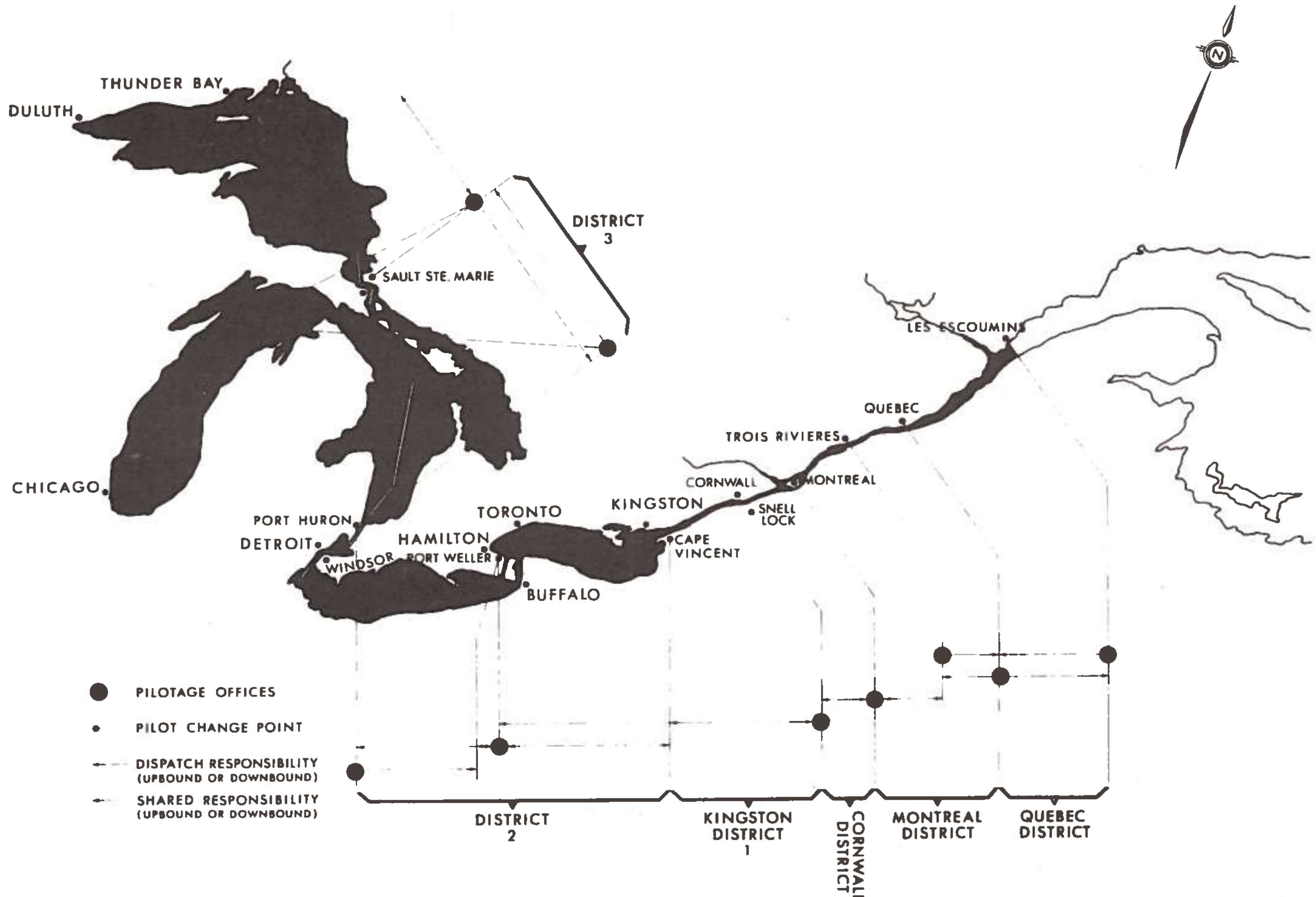


Figure 3-4 St. Lawrence-Great Lakes Pilotage Responsibility

vessel progress through the locks. This data is collected off-line and will evolve eventually into an on-line capability.

In the Welland Canal section including Lake Ontario, and portions of Lake Erie, a computerized traffic control system (vessel surveillance) has been developed and tested. This system consisting of a mini-computer and Cathode Ray Tube (CRT) input/output terminals has provided a semi-automated traffic control system and has successfully shown, in terms of improved canal performance, the capability of this system to record, store and distribute pertinent information. Both sections have installed a closed circuit television system which provides positive vessel control within critical lock areas. This visual capability, backed-up with mechanically driven display devices, provide rudimentary traffic control over Montreal-Lake Ontario and Welland section operations.

The U.S. role in traffic control on the St. Lawrence River is centered about operations of the Snell and Eisenhower Locks and the Thousand Islands section of the River. The U.S. uses manual control through its sectors of responsibility augmented by closed circuit television within the vicinity of the locks. Lock data are collected by ultrasonic sensors mounted on each lock wall. The Control Center is maintained at the Eisenhower Lock at Massena, New York.

3.6.2 Control Sectors

Currently there are seven control sectors in the St. Lawrence Seaway. Four of these sectors are all Canadian, two comprise a joint U.S.-Canadian operation and one wholly U.S. (Figure 3-5) The Montreal, Quebec and Port Weller Control sectors are operated by the Canadian Ministry of Transport. St. Catharines Control is operated by the St. Lawrence Seaway Authority. The Montreal to Lake Ontario section is operated jointly by the U.S. and Canada. The St. Lambert sector (subsectors 1 and 3) is the responsibility of the St. Lawrence Seaway Authority. The Massena sector (subsectors 2 and 4), the responsibility of the St. Lawrence Seaway Development Corporation. All the above sectors are interrelated. Operations at the Sault Ste. Marie are independent. In this region four of the five locks are U.S. and are controlled by the U.S. Army, Corps of Engineers. The remaining lock is Canadian and controlled by the St. Lawrence Seaway Authority.

3.6.3 Communications

The control centers, the Canadian ports, pilotage offices, and radio offices in the Lower Great Lakes and the St. Lawrence River plus the operational headquarters of the St. Lawrence Seaway Authority at Cornwall, Ontario are linked together by a teletype network. Currently there are nine teletype station-to-station landlines serving seven Canadian and two U.S. entities. (Figure 3-6).

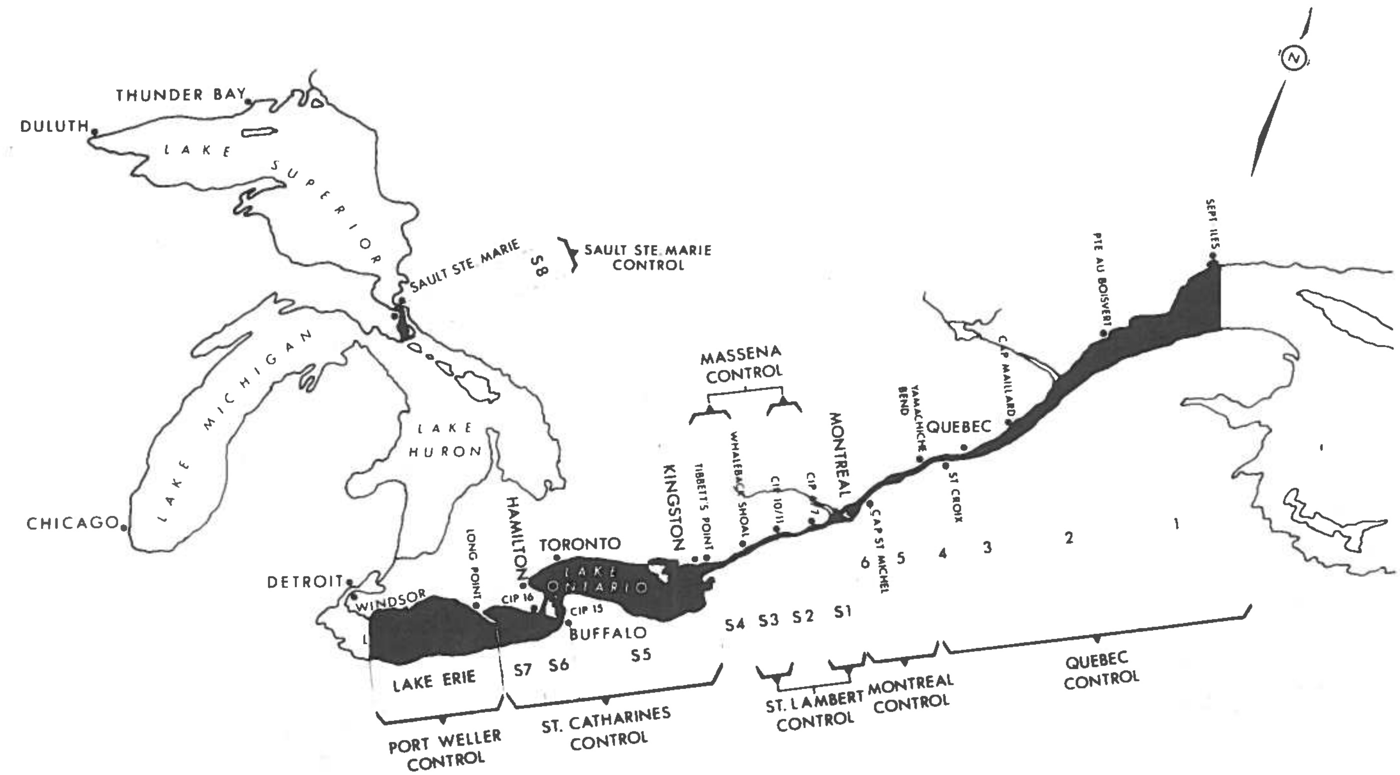


Figure 3-5 St. Lawrence-Great Lakes Present Traffic Control Sectors (1970)

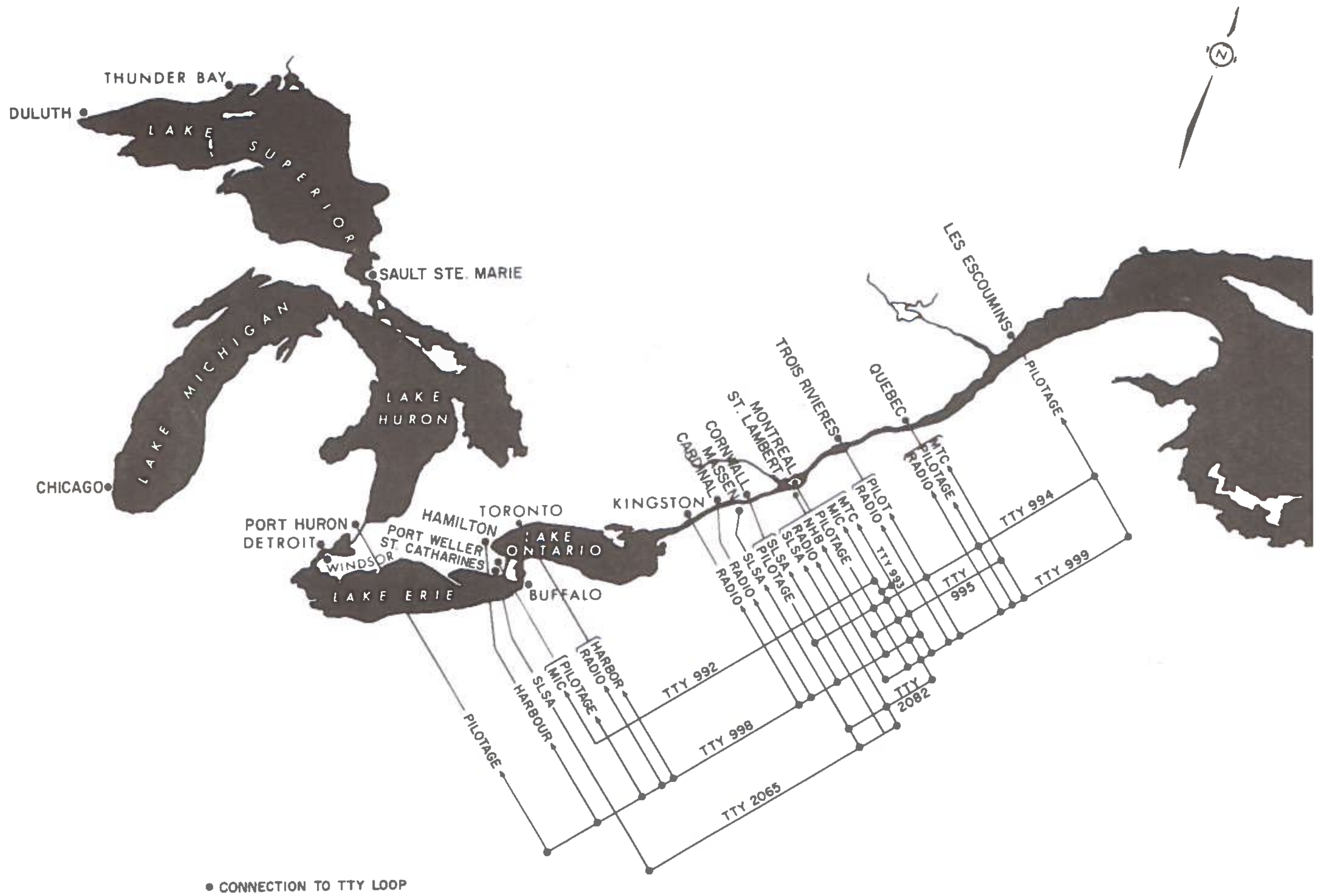


Figure 3-6 St. Lawrence-Great Lakes Data Communications Teletype Network

This network provides for exchange of traffic and cargo information, weather and pilotage data. Though interrelated through a limited message switching capability they are not entirely interconnected. Thus, often times for a message to be transmitted from one station to another not on the same link, it must first be transmitted to a common station and then manually retransmitted to the ultimate destination.

In addition to the land line teletype network, there is a VHF Radio network which links vessels, and control stations. The radiating pattern for the Seaway radio network is limited to 30 miles and 50 miles for the St. Lawrence River-Lake Ontario and Lake Erie areas respectively. This limitation inhibits cross talk between reporting areas and provides an overlapping pattern for adjacent areas. In addition, FM channels are available for ship to ship communications in the lakes and canals.

3.6.4 Vessel Reporting and Tracking

Approximately every fourteen miles between the mouth of the St. Lawrence River and the Welland Canal a vessel must call in to the cognizant traffic control center and report its current position. Between the Welland Canal and the Western end of Lake Erie the call-in points are 25 miles apart. In addition there are call-in points at either end of the Sault Ste. Marie. No other call-in points are currently in use in the Seaway. At each call-in point the vessel reports his speed and estimated time of arrival at the next point. If the vessel is 30 minutes late in reporting, then a search is initiated. Vessel tracking and location is by exception only, positive tracking does not exist in the Seaway system.

4.0 DEMAND ANALYSIS AND PROJECTIONS

4.1 INTRODUCTION AND ASSUMPTIONS

The assumptions underlying the projections in this section are based upon the ability of the Seaway system elements to enhance rather than constrain the system; that is, the Seaway is optimized about the characteristics of each of its components. Secondly, the Seaway is assumed to continue to carry at least 3.5 percent of the total U.S. overseas waterborne tonnage. The effect of an upward shift in this figure is not included. Finally the legislative, labor, marketing and environmental externalities which could effect demand and commodity flows are not considered. Such impacts could include strikes, shipping season extension, Great Lakes marketing activities, and legislative programs such as the Domestic International Sales Corporation (DISC) to encourage overseas trade.

These projections indicate a steady increase in total tons carried through the system without a similar increase in transits. Toward the latter portion of the period however, there will be a slight upward trend in transits. The tonnage increases are attributable to a growth in vessel cargo capacity, and a replacement of aging carriers with higher capacity carriers. The vessel replacements will probably be less than a one-to-one old-to-new vessel ratio. In addition, the ratio of ocean vessels to lake vessels will also increase and will be due principally to the greater utilization of the Seaway and Fourth Coast trading area by ocean going vessels and to a shift in commodity flow patterns.

4.2 PRINCIPAL COMMODITY FLOWS

The commodities carried through the Montreal-Lake Ontario and Welland sections of the Seaway system represent a broad cross section of water-borne commerce. However, there are nine categories of cargo which represent approximately seventy-five percent of the annual tonnage through the system. By examining these categories and their expected utilization, an indication of potential goods movements can be derived.

The principal commodities carried through the system are: iron ore, coal, limestone, petroleum, wheat, corn, soybeans, manufactured and scrap iron and steel. Table 4-1 summarizes the principal commodity flows as a percent of total cargo tonnage through the Welland and St. Lawrence sections for the year 1969. Also shown on this table is the predicted change in commodity flow. These data and predicted changes are based on References 14 and 15.

Iron ore represents the major cargo movement through the Welland and Montreal-Lake Ontario sections of the system, and is characterized principally by upbound flows representing backhauled iron ore from the Canadian-Labrador region to the Great Lakes steel mills.

TABLE 4-1 1969 PRINCIPAL COMMODITY FLOW ANALYSIS - PERCENT OF TOTAL CARGO TONNAGE

Commodity	Welland	St. Lawrence River	Predicted Change	
			Welland	St. Lawrence
Mineral				
Iron Ore	25	28	UP	UP
Coal	20	-	N/C	N/C
Limestone	3	-	N/C	N/C
Petroleum	3	8	N/C	UP
Agriculture				
Wheat	10	12	UP	UP
Corn	7	9	N/C	N/C
Soy Bean	4	4	N/C	N/C
Lumber	-	-	UP	-
Iron & Steel				
Mfg	7	10	UP	UP
Scrap	2.3	3.2	N/C	N/C
Sub-total	81	74		
Flow				
UP	36.2	54.7	UP	DOWN
DOWN	63.8	45.3	DOWN	UP

In 1969, the Lake Superior district supplied fifty-three percent of the U. S. national iron ore requirements. Most of this movement was Upper Lake and did not pass through the Welland Canal or the St. Lawrence River. Other U. S. sources supplied fifteen percent. The remaining U. S. iron ore requirement was derived from imported sources, principally from the Labrador region (15%)and the Venezuela-Brazil region (14%). The ore from the former source passed through both sections of the Seaway. Although the iron ore reserves in the Lake Superior district are ample to last into the early years of the next century, there will be a shift towards imported sources. This shift will be noticeable in the next decade and heavy in the post-1985 period. The effect of this shift will be to increase iron ore tonnage upbound through the Montreal-Lake Ontario and Welland sections of the system.

Coal shipments are short haul, interlake cargo movements principally from Lake Erie ports through the Welland Canal to Lake Ontario ports. The Pennsylvania coal fields are a principal supplier to Ontario thermal power plants. Even though some Ontario utilities are planning conversion to oil and gas, coal usage is expected to remain fairly constant over the next several decades. Similarly, limestone traffic through the Welland Canal is not expected to change.

Current traffic patterns for petroleum indicate an upbound movement of overseas imports. Two-thirds of this traffic has its destination in Lake Ontario ports, the remainder continue through the Welland Canal. In the next several decades, there could be a shift in this pattern. As the Alberta oil fields are developed and grow, they could become a major source for Eastern Canada's (east of Kingston, Ontario) petroleum needs. This petroleum would probably be shipped by water via Lake Ontario ports down the St. Lawrence River to Quebec ports. This shift in traffic pattern would probably not impact on the Welland Canal, but would affect St. Lawrence section traffic.

Wheat is the principal agricultural commodity carried through the St. Lawrence Seaway. The historic pattern has been from Lakehead ports down to Canadian ports on the lower portion of the St. Lawrence River for transshipment overseas. This flow is of interest since it represents a backhaul for the iron ore from Labrador mines. Six percent of the U. S. hinterland wheat now flows through the Seaway. With the northeast U. S. and Soviet Union trade needs established, the percent share of the market should grow. In addition, recently the Canada Wheat Board has preferred to ship wheat grown in the prairie provinces of Manitoba, Saskatchewan and Alberta via the Lakehead and Seaway instead of Vancouver in order to relieve congestion on the railroads to Vancouver. This decision will impact immediately on the short range tonnage predictions. The longer range effect is undetermined. Overall, the U. S.-Canadian wheat traffic through the Welland and St. Lawrence sections is expected to rise.

Corn and soybeans represent the other major agricultural products carried via the Seaway. The principal flows for these commodities are downbound through the Welland and St. Lawrence sections. No change is predicted in either the pattern or relative percent carried through the system for either commodity.

Reference 14 has indicated that significant rate savings exist for western lumber shipped by rail and water via Duluth to Lower Lakes and St. Lawrence River ports. The potential for this mode of shipment suggests an additional major commodity for the St. Lawrence Seaway system. This traffic pattern would affect the Welland Canal, Lake Ontario and upper New York State ports.

Iron and steel, principally manufactured iron and steel, is a major commodity for both the Welland and the St. Lawrence River sections. It represents a substantial movement in both directions, but principally upbound. Recently (1971), however, automotive parts manufacturers have discovered significantly lower U. S. to Europe shipping costs via the Seaway. In addition, overall U.S. exports have been increasing at an annual rate of nine percent. These factors impact on downbound cargo movements through both sections of the system. Hence, an increase in downbound tonnage is predicted for this commodity. Although a substantial portion of scrap iron and steel is carried downbound through the system to overseas ports, the percent of the total system cargo tonnage attributable to this commodity is expected to remain unchanged.

Overall, the commodity movements for both the Welland and St. Lawrence sections are expected to equalize in both directions.

4.3 PROJECTED TONNAGES

The precision of the projections of the tonnages expected through the St. Lawrence Seaway a decade or more in the future is subject to the normal uncertainties of trade and commerce, the Canadian and U. S. shares of world trade, the progress of competing transportation systems and the impact of advancements in transportation technology. The uncertainties in the forecasts in the post-1980 period are reflected in a range of values bounded by a high and low value. These extremes include normal variations but do not allow for all possible contingencies. For example, year to year variations in Seaway tonnages can occur due to general fluctuations in the economy, particularly in export sales of such commodities as grain and iron ore. These fluctuations are generally unpredictable, often attributable to acts of God and cannot be projected realistically. These fluctuations have been damped out of the tonnage projections.

The forecasts are divided into the Montreal-Lake Ontario section and the Welland Canal section and are based upon the St. Lawrence Seaway Development Corporation, the St. Lawrence Seaway Authority, the U.S. Army Corps of Engineers Traffic Reports, and projections in the Stanford Research Institute, EBS, Kates, Carr and Reebie consultant reports (References 1-6, 14,15).

4.3.1. Montreal-Lake Ontario Section

The cargo tonnage carried by the lake and ocean vessels through the Montreal-Lake Ontario section of the system has been increasing at approximately one million tons per year (Figure 4-1). The laker traffic is principally wheat and backhauled iron ore with the upbound iron ore over-compensating for the downbound wheat traffic. The 1967-1969 years were particularly poor for grain sales and hence the downward tendency shown on the inland vessel carriers for that period. Ocean traffic has shown a steady increase since Seaway opening. During this period ocean carried exports have generally exceeded imports by two to three million cargo tons each year except 1968, see Figure 4-2.

Table 4-2 summarizes the percentage of total cargo carried by ocean and lake vessels. During this period the effect of longshoremen's strikes on the East and West coast has impacted on Seaway traffic distribution. Because of these effects there is a trend towards higher overseas demand. This trend is expected to continue and stabilize around a 40/60 ocean/laker mix.

The historic and projected growth patterns are shown in Table 4-3. This table indicates a sustained rate of growth throughout the thirty-year period 1961-1990, reflecting a positive trend in Seaway demand. This demand is evidenced by an approximately twelve percent annual growth rate in the first decade. The subsequent decade (1971-1980) shows an overall annual growth of 3.8 percent. This reduction in growth rate is due principally to a stabilization of the inland market demand through 1980. If the Mesabi Range depletion predictions are valid, then the market demand for imported (inland traffic) iron ore will increase in the mid 1980's. Ocean vessel tonnage growth is sustained at the previous level. In 1980 the overall tonnage is expected to reach 70 million tons. Two projections are shown for the 1981-1990 period. The first reflects a continuation of the 1971-1980 growth rate; the second a tapering off in demand to one-third that sustained in the previous decade. The 1990 tonnage values corresponding to these projections are 96.5 and 80 million tons respectively.

4.3.2 Welland Section

Tonnages through the Welland section of the St. Lawrence Seaway system have been increasing at approximately 4 million tons per year (Figure 4-3). These tonnages consist principally of the wheat-backhauled iron ore traffic and the short haul Lake Erie-Lake Ontario coal traffic. Strikes and poor wheat sales have principally accounted for the drops in total tonnage and/or inland vessel tonnage in the years 1967, 1969 and 1971. However, the ocean vessel tonnage has shown a steady increase similar to that in the Montreal-Lake Ontario section, with exports exceeding imports by approximately 2 to 3 million tons per year (Figure 4-4). As compared with the Montreal-Lake Ontario section, the Welland

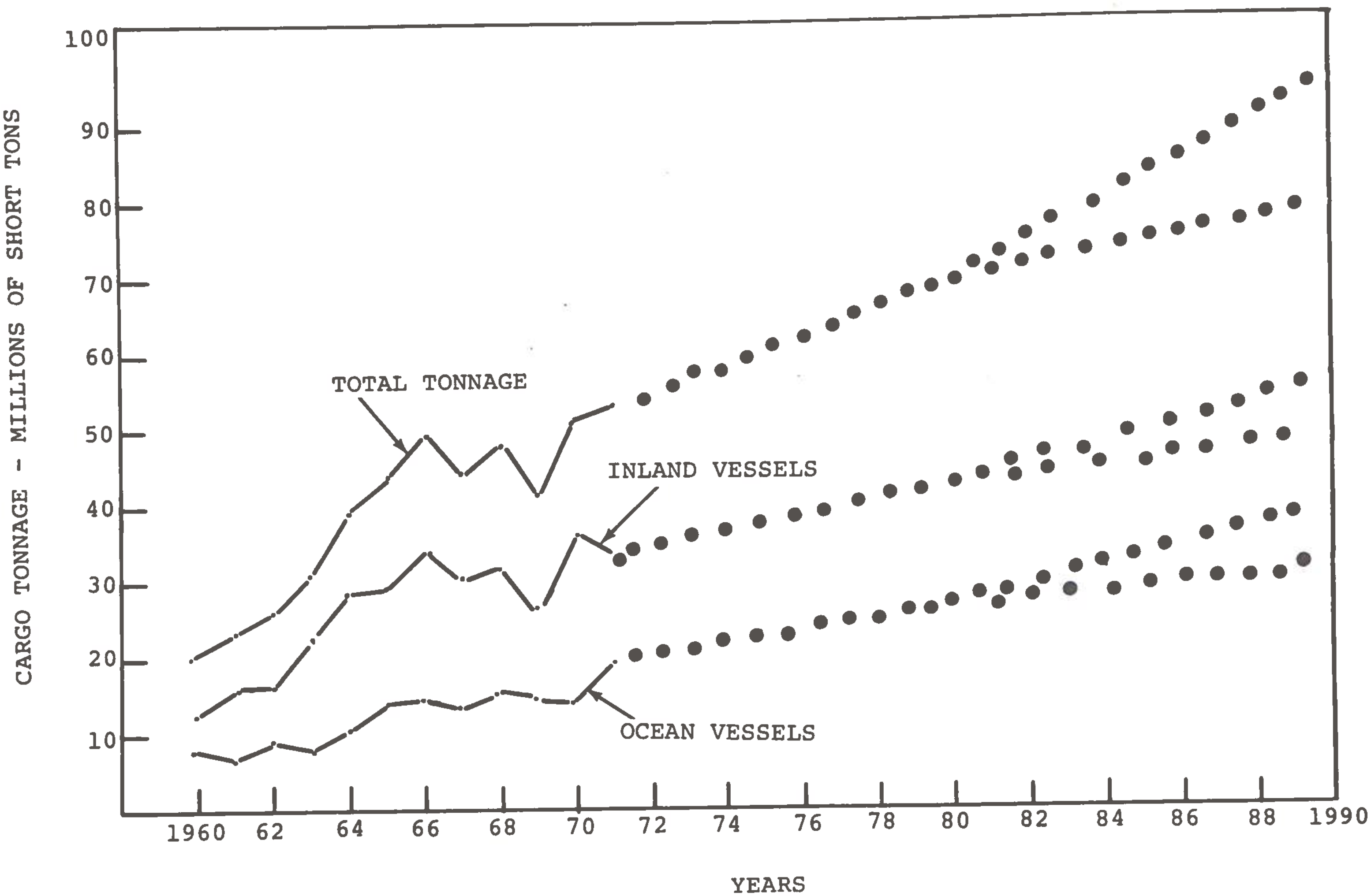


Figure 4-1 Montreal-Lake Ontario Section Annual Cargo Tonnages

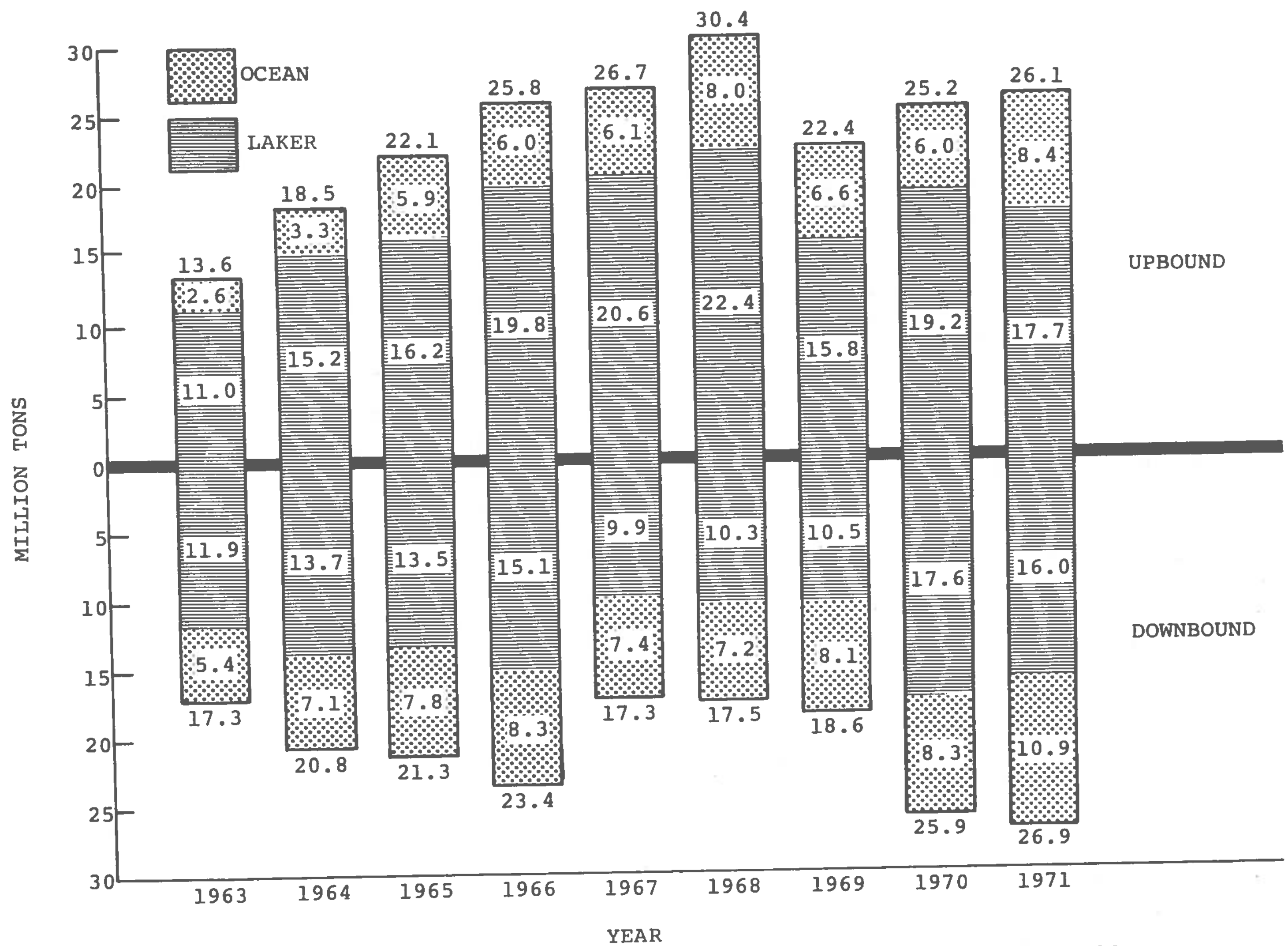


Figure 4-2 Montreal-Lake Ontario Section Ocean and Laker Traffic

TABLE 4-2 PERCENT OF TOTAL CARGO CARRIED THROUGH MONTREAL-LAKE ONTARIO SECTION

YEAR	OCEAN	LAKER
1963	25.7	74.3
1964	26.4	73.6
1965	31.1	68.9
1966	29.1	70.9
1967	30.7	69.3 (Seaway Strike)
1968	31.8	68.2 (Mariners Strike)
1969	37.8	62.2 (Strike Effect)
1970	27.9	72.1
1971	26.4	63.6 (Strike Effect)

TABLE 4-3 MONTREAL-LAKE ONTARIO SECTION 30 YEAR GROWTH PATTERNS - MILLIONS OF TONS

	1961-1970		1971-1980		1981-1990	
	Growth Tons	Annual %	Growth Tons	Annual %	Growth Tons	Annual %
OCEAN	6.9	9.3	12.7	8.9	6-13	1.4-3.0
LAKER	20.7	12.9	6.6	1.8	3-13	1.1-4.8
COMPOSITE	27.6	11.7	19.3	3.8	9-26	1.2-3.7

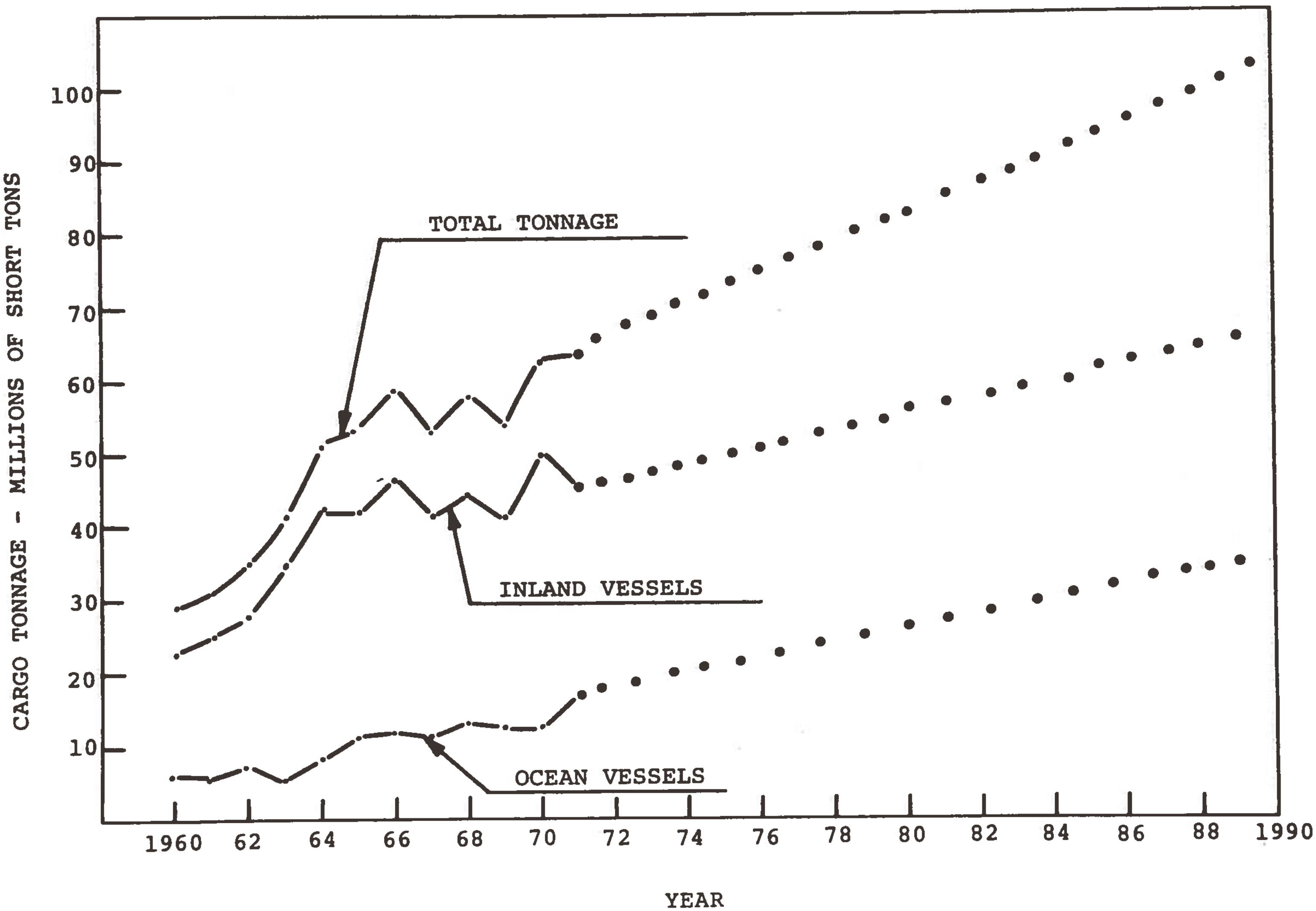


Figure 4-3 Welland Section Annual Cargo Tonnages

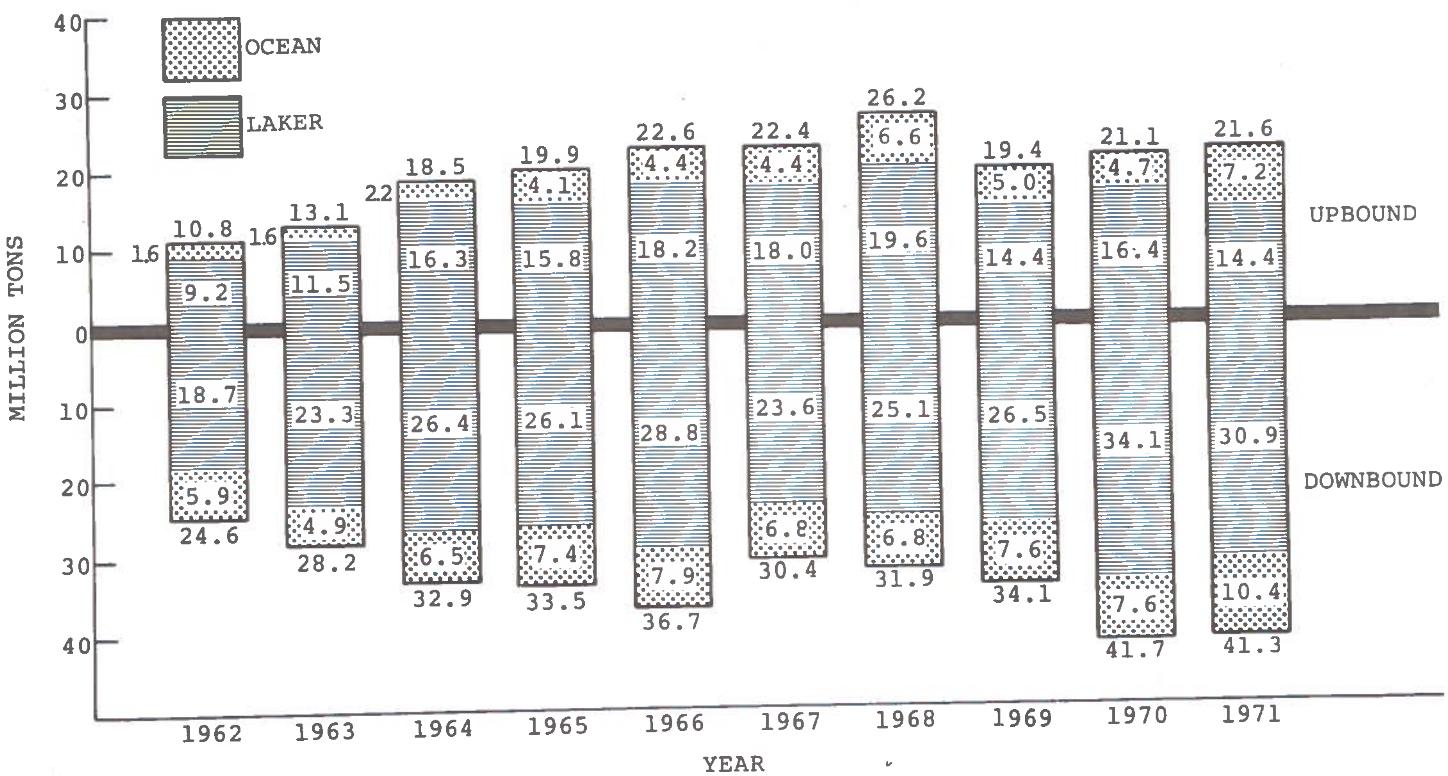


Figure 4-4 Welland Section Ocean and Laker Traffic

section has an historic pattern of approximately 10 million tons more annual traffic. The bituminous coal traffic is the principal factor accounting for this differential.

Table 4-4 summarizes the percent of total Welland section cargo tonnages carried by ocean and lake vessels. This table shows that there has been a steady shift towards overseas demand over the period covered. In particular, the effect of the longshoreman's strike in 1971 has shown a significant trend in the overseas demand (32 percent increase over 1970). This shift towards ocean borne tonnages is expected to continue.

The thirty year growth patterns are shown in Table 4-5. During the 1961-1970 decade, the ocean and lake tonnage growth rate was practically identical, averaging nearly 10 percent per year. In the projected periods, 1971-1980 and 1981-1990 the the absolute growth in tonnage for ocean and lake vessels is expected to be nearly identical, however, the growth rate for the ocean vessels will be approximately twice that of the inland vessels. Overall, a 3% annual rate is projected for 1971-1980 tapering off to a 2.2% rate for the post 1980 period. These rates will represent a total tonnage figure of 83 million tons in 1980 and 104 million tons in 1990.

The significance of these projections lies not so much in the figures per se but rather in the strong upward trend they represent. This trend is indicative of an increased demand for the Seaway facilities and projects a continuing requirement for a greater level of service through reduced delays and enhanced safety.

4.4 PROJECTED TRANSITS AND TONS PER TRANSIT

Data over the past five years have indicated a marked trend toward a reduction in the number of yearly transits. Figures 4-5 and 4-6 present these data for the period 1959 to 1971 for the Montreal-Lake Ontario and the Welland Canal sections of the St. Lawrence Seaway system. As can be seen, the total number of transits steadily diminished in this period. These data are indicative of the trend away from low capacity ships and toward a fleet of larger, broader beamed, higher capacity vessels. Thus, while the annual tonnage through the two sections of the system is increasing, the total number of transits per year is decreasing resulting in a net increase in average cargo tonnage per transit per year. See Figures 4-7 and 4-8.

Transits are currently at a ratio of 60-40 lake to ocean vessels in the Montreal-Lake Ontario section (1970 data). This ratio is expected to shift slightly and stabilize about a 55-45 laker to ocean figure. In the Welland section the current ratio is 65-35 with a trend towards 60-40 forecast in the next 20 years. These figures indicate that the ocean and lake vessel transits are tending toward an equilibrium condition wherein little growth is indicated.

TABLE 4-4 PERCENT OF TOTAL CARGO CARRIED THROUGH WELLAND SECTION

YEAR	OCEAN	LAKER
1963	15.7	84.3
1964	16.9	83.1
1965	21.5	78.5
1966	20.7	79.3
1967	21.3	78.7 (Seaway Strike)
1968	23.0	77.0 (Mariners Strike)
1969	23.5	76.6 (Strike Effect)
1970	19.7	80.3
1971	27.3	72.7 (Strike Effect)

TABLE 4-5 WELLAND SECTION 30 YEAR GROWTH PATTERNS - MILLIONS OF TONS

	1961-1970		1971-1980		1981-1990	
	Growth Tons	Annual %	Growth Tons	Annual %	Growth Tons	Annual %
OCEAN	6.1	9.1	9.0	5.1	8.5	3.0
LAKER	25.3	10.0	10.0	2.2	10.0	1.8
COMPOSITE	31.4	9.8	19.0	3.0	18.5	2.2

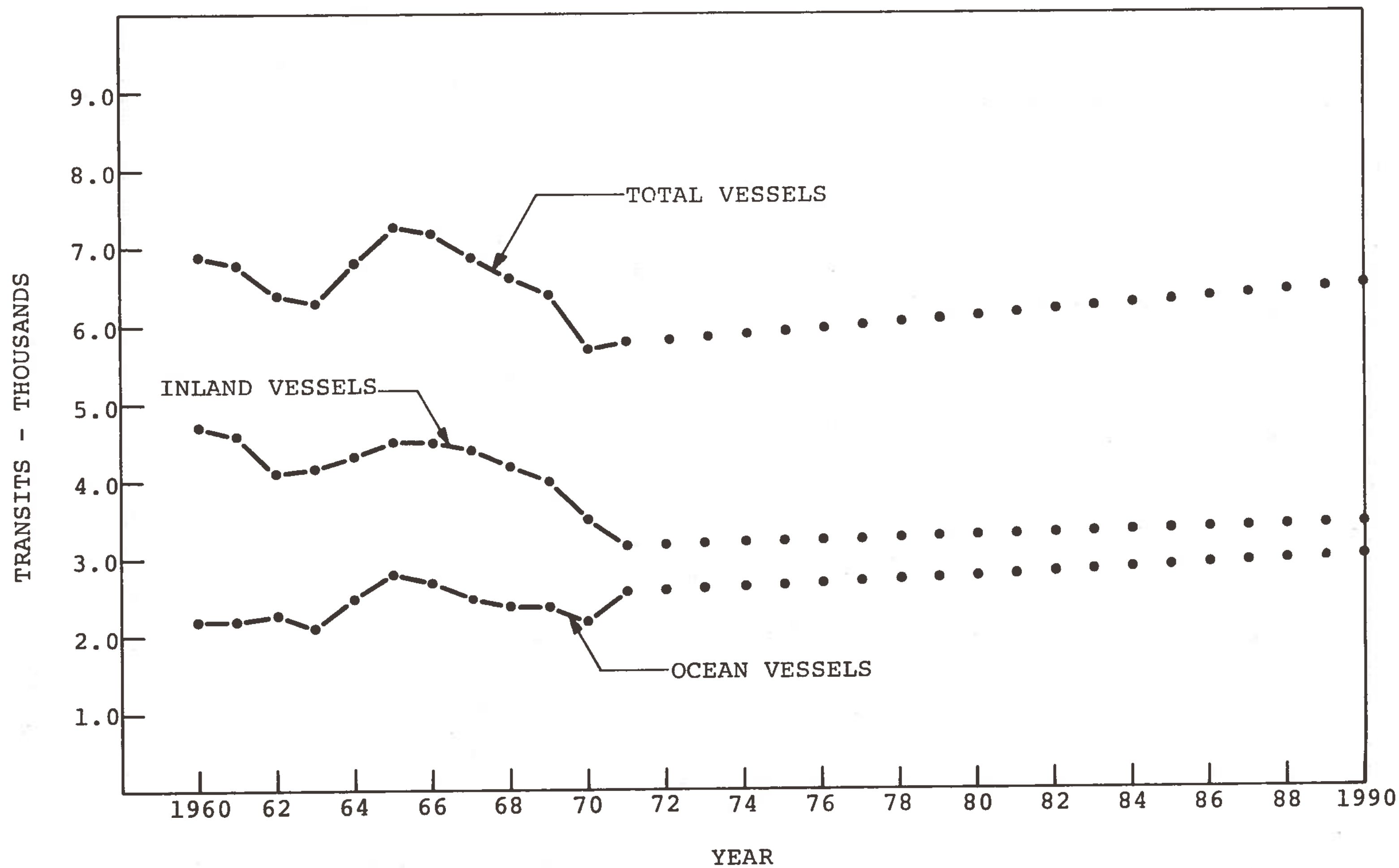


Figure 4-5 Montreal-Lake Ontario Section Number of Transits Per Year

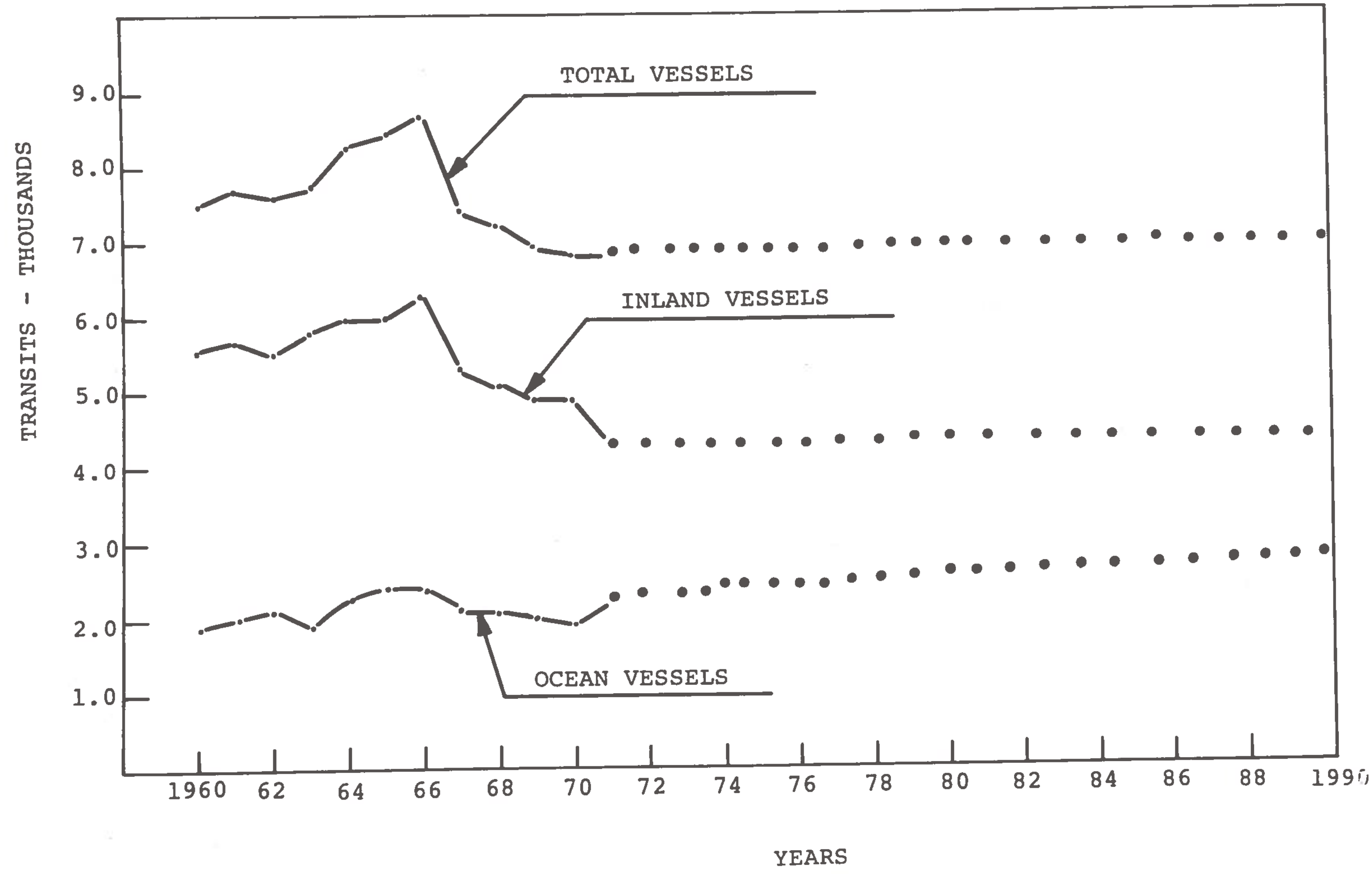


Figure 4-6 Welland Section Number of Transits Per Year

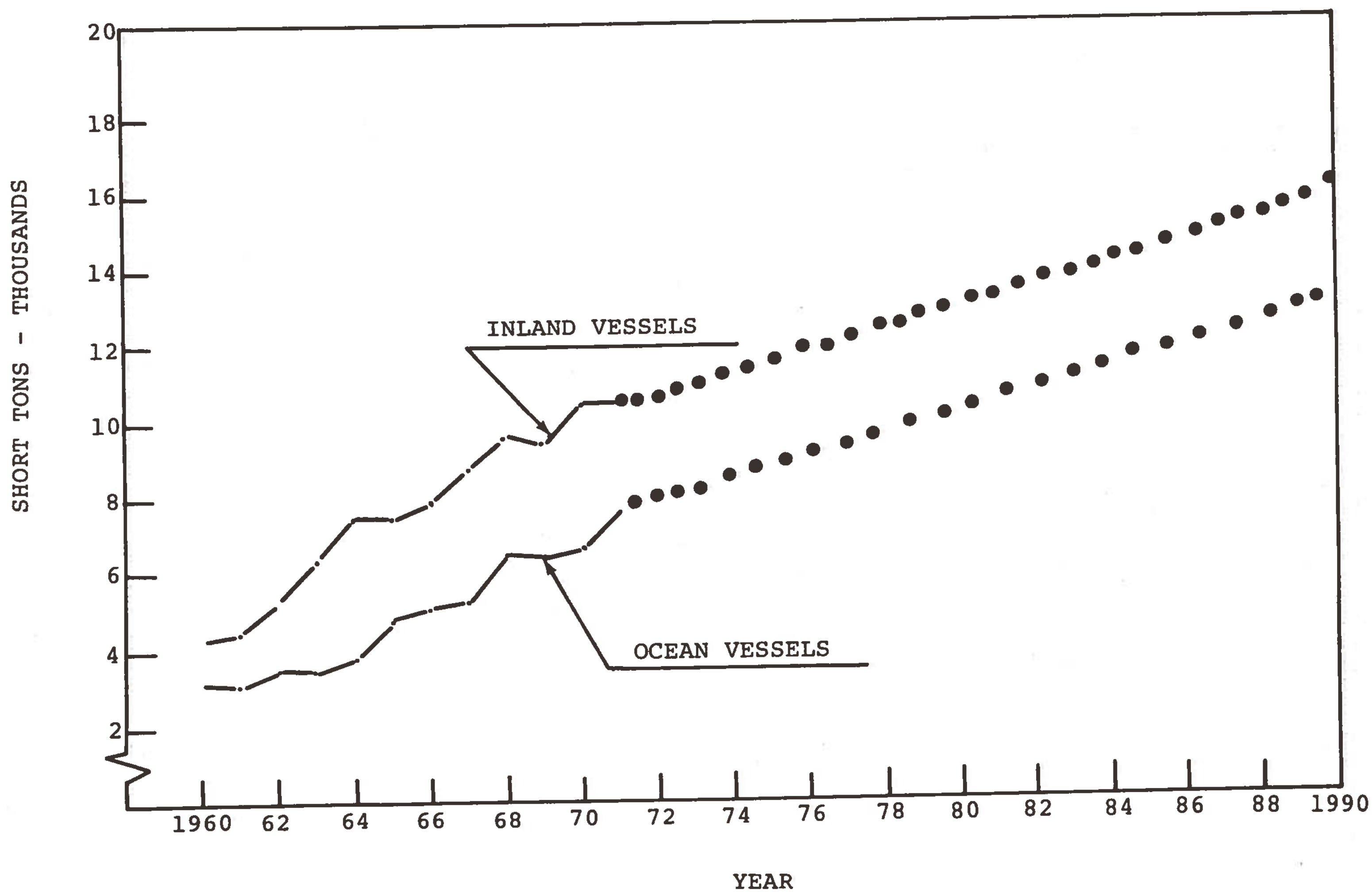


Figure 4-7 Montreal-Lake Ontario Section Average Cargo-Tonnage/Transit

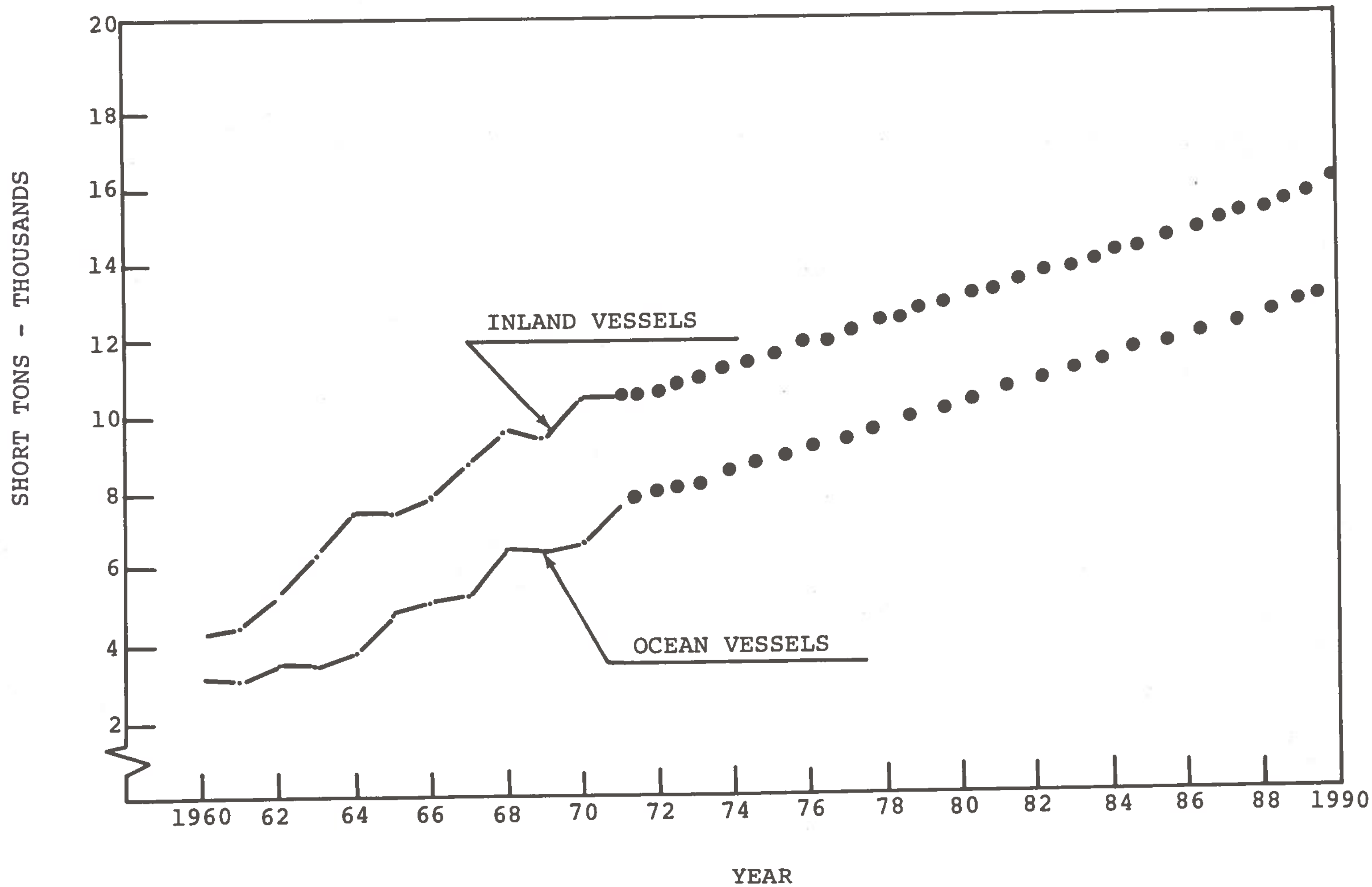


Figure 4-8 Welland Section Average Cargo-Tonnage/Transit

The annual number of laker transits decreased sharply in the mid 1960's. Accompanying this downward trend in transits was an upward trend in average cargo tonnage carried per transit. The principal reason for this trend is the advent of the 730 foot lake carrier. This class of ships is the maximum size vessel which can be accommodated in the system within the constraints of the lock configuration. In the period 1959-1969, thirty-eight of these vessels were placed in service in the Welland and St. Lawrence sections. Two more are planned to enter in 1972 and one in 1973. Despite the presence of the 730 fleet the strike years of 1967, 1968, 1969, and 1971 have shown sharp drops in transits or in average tonnage per transit depending on the entity or commodity affected.

In 1971 the average tonnage per transit for lakers on both the Welland and Montreal-Lake Ontario sections was 10,400 tons. Based upon a forecast of a relatively unchanged number of transits, and a constant increase in the total annual tonnage, the average tonnage per transit must rise in the next 20 years. In 1980 the average would be 13,400 tons and by 1990, this average will reach 16,000 tons and be reflected in better balanced loading between iron ore and wheat. The figures are forecasted for both the Welland and St. Lawrence sections. The implications from these forecasts are for an increase in retirement from the system of the smaller, lower capacity vessels and for their replacement with larger capacity carriers. Failing this, total fleet capacity will not equal demand for the system.

The annual number of ocean vessel transits has been relatively constant since 1960 (Figures 4-5 and 4-6). During this period there has been an average difference of approximately 300 fewer transits per year through the Welland section. This differential is expected to be diminished in the future. A slight annual increase in transits through both sections is forecast based on the assumption that cargo carriage capacities, although continuing to grow, will not increase in size rapidly enough to meet the demand. In 1971, the average ocean vessel tonnage per transit was 7400 tons in the Montreal-Lake Ontario section and 7700 tons in the Welland section. In 1980, these figures are expected to be 10,300 for both sections while in 1990 the average tonnage will have reached 13,000 tons.

4.5 VESSEL SIZING

In the 1971-1980 and 1981-1990 periods Seaway utilization has been predicted to increase. This increase is a function of both greater tonnage and greater number of ships transitting the facility. To achieve this predicted level of capability, not only must vessels of greater length and beam (and hence capacity) be added to the system, but also ships of marginal productivity must be retired from the Seaway fleet.

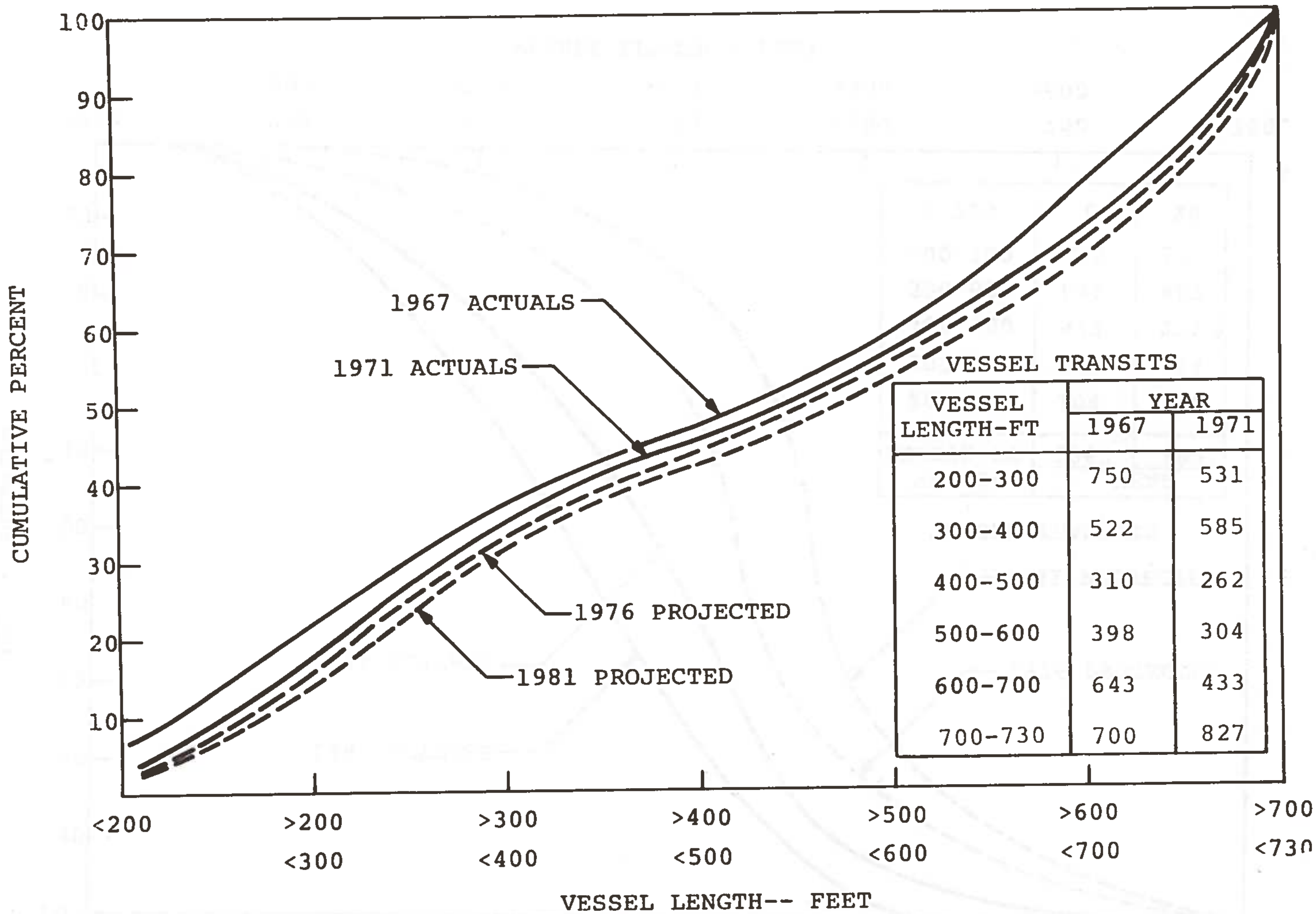
Impacting on the older, smaller, marginally productive vessels are the renewal marine insurance rates. For vessels 30 years of age and older, insurance rates are so costly that profitable operations are prohibited. Since 1963, every four year period has seen over 200 older, smaller vessels removed from the Seaway fleet. In 1969, 55 percent of the fleet was over 30 years old and 65 percent was over 20 years old. The historic trend indicates that these ships will be retired shortly.

There is a world wide trend toward the construction of larger vessels both in the inland and ocean class. As these "super" vessels enter the fleets the ships they displace could be made available for Seaway operations. For example, the inland traffic through the Welland Canal represents principally Canadian vessels since the U.S. laker fleet is oonfined to traffic moving between the Upper Lakes and does not utilize the Welland section. However, in the near future, this Welland Canal pattern may change. The new 1200 foot long (pintle to pintle) Poe Locks in the Sault Ste. Marie Canal are creating a demand for a new "super laker" class of vessels to be accommodated in these locks. It is possible that these new large lake vessels will displace the 600-700 foot vessels from the Upper Lake pattern and divert them to the Welland Canal traffic. Similarily, as more giant tanker and cargo vessels enter the ocean fleet, more 600-700 foot ocean vessels could be freed for Great Lakes service.

The optimum upper limit for lakers is 730 foot length, 27 foot draft and 75.5 foot beam, 25,500 cargo tons capacity. Since 1959, 40 of these vessels have been launched, 38 are used in Montreal-Lake Ontario and Welland section service. Three more will be launched and in service by 1974. The impact of the introduction of the 730 foot laker is shown in Figure 4-9. This figure shows the historic and projected shift in inland vessel length as a function of the number of transits made by vessels in each length category. This figure indicates that in the period 1967-1971 the laker fleet increased its average length overall (LOA) by 20 feet. During this period, the cargo carriage capacity increased by 2000 tons. Thus, for each foot of growth in LOA, cargo capacity increases by 100 tons. In the 1967-1969 period this rate of growth of cargo capacity exceeded the rate of cargo demand. (The overall drop in demand during this period was principally due to a transient drop in wheat demand). Despite this temporary excess capacity the LOA growth rate continued into 1971 and is expected to continue at approximately this rate. By 1981 the average length overall of laker vessels based upon the number of transits will have increased by 36 feet from that of 1971. This corresponds to an additional capacity of 3600 tons and is equivalent to a projected average tons per transit of nearly 14,000 tons.

Figure 4-9 also shows an actual and projected drop in the number of transits made by smaller class vessels indicating improved fleet utilization efficiency in terms of tonnage per transit.

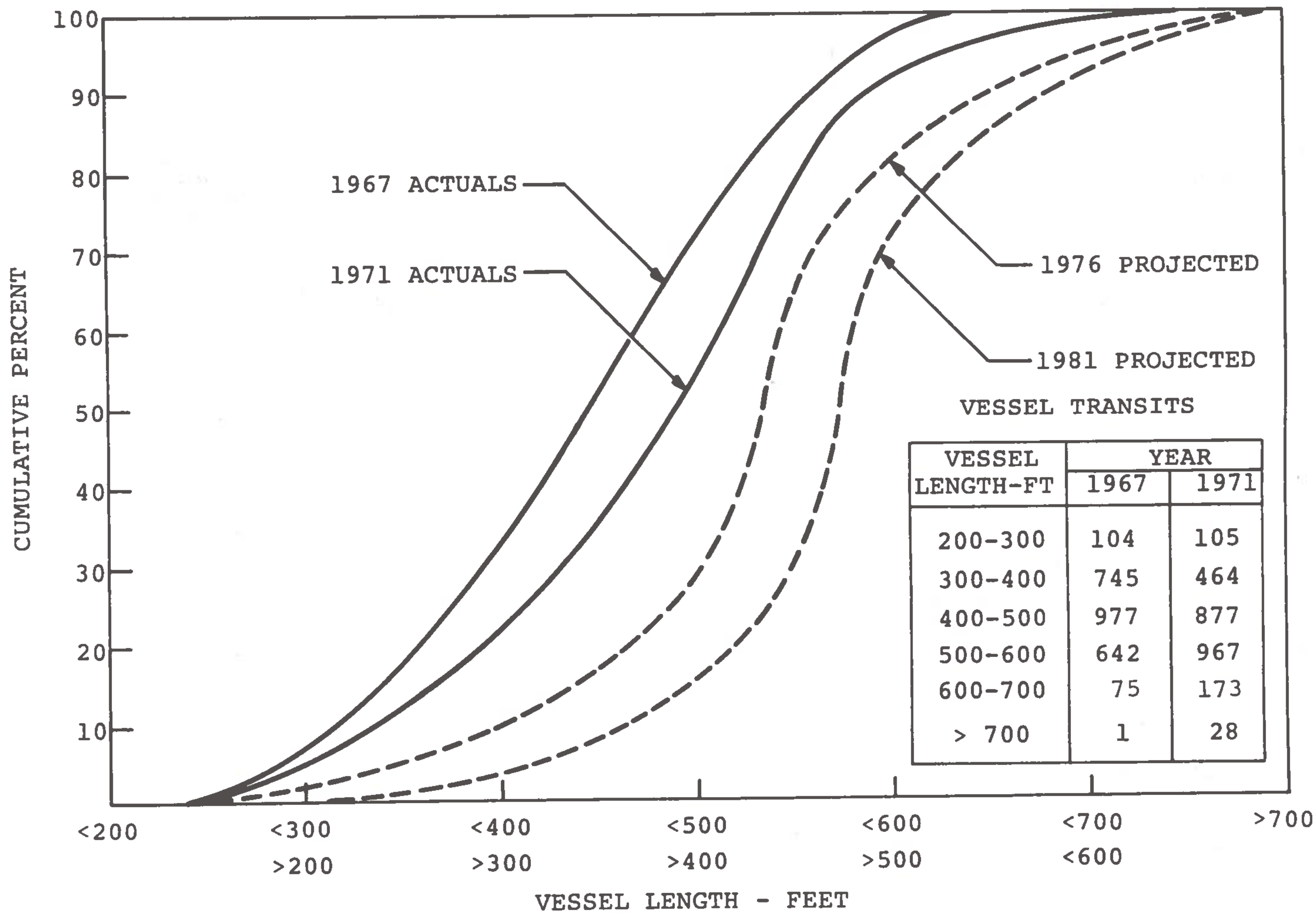
The optimum design limits for ocean vessels is 709 foot length, 75 foot beam, 26 foot draft and 20,800 cargo tons capacity. In the period 1967-1971, the average LOA for ocean vessels increased more rapidly than that of the lake vessels (Figure 4-10). This



VESSEL TRANSITS

VESSEL LENGTH-FT	YEAR 1967	YEAR 1971
200-300	750	531
300-400	522	585
400-500	310	262
500-600	398	304
600-700	643	433
700-730	700	827

Figure 4-9 Distribution of Inland Vessel Transits



VESSEL TRANSITS

VESSEL LENGTH-FT	YEAR 1967	1971
200-300	104	105
300-400	745	464
400-500	977	877
500-600	642	967
600-700	75	173
> 700	1	28

Figure 4-10 Distribution of Ocean Vessel Transits

differential is probably due to the fact that the majority of the 730 foot lake vessels were introduced prior to 1967, while the 709 foot ocean vessels are now starting to join the Seaway fleet and their impact has yet to be fully felt. Since 1967, this average LOA for ocean vessels has increased by 12 feet per year. This trend is expected to continue through 1981. However, the increase in cargo tons per transit has not been as effective as lake vessels since each foot of increase represents only a 50 ton per transit increase. This effect is probably due to differences in cargo density and vessel design. By 1981 the average LOA is projected to increase by 88 feet which corresponds to a 4480 tons per transit increase, and will represent an average tons per transit of over 11,000 tons. If the ocean vessels are to meet the projected demand, their sizes and capacities must grow in the next 20 years. If the overseas demand should be greater than forecast, the number of vessel transits will rise more rapidly than predicted and the system will become saturated sooner.

The foregoing discussion on shifts and increases in fleet mix are predicted on the basis of past trends and forecast demand. The political externalities to fleet replacement and modernization have not been included in these studies but could provide an even greater impetus for Seaway shipbuilding. Such factors as legislative incentives, e.g., the Merchant Marine Act of 1936 as amended, could create a favorable environment for Seaway vessel upgrading and fleet expansion. In addition, it is possible that the Maritime Administration may subsidize the U. S. lake fleet in the near future. Thus there appears to be a strong, positive political environment for an increase in the number and size of Seaway vessels.

5.0 SEAWAY CAPACITY

5.1 DEFINITION

Seaway capacity can be defined it terms of throughput (i.e. maximum number of vessels transitting the system), or tonnage carried within the system in a given period of time, or a combination of the two expressed as ton-miles. All of these definitions are considered in this section. Related factors which affect Seaway capacity include weather, operational constraints, vessel arrival rate, lock service time and vessel characteristics and mix. In the context of this analysis, these factors are relevant to a determination of capacity.

5.2 VESSEL THROUGHPUT

Considering the characteristics and dynamics of the Seaway facilities, lock throughput is the primary factor influencing Seaway capacity. The bottleneck or slowest lock tends to constrain the system throughput. The constraining locks in the Seaway system are the Beauharnois Locks, a system of paired locks in the Montreal-Lake Ontario section. One-way throughputs through each lock are averaging forty-five minutes; for larger vessels such as the 730 foot lakers, this time approaches sixty-five minutes. The capacity of the system thus is directly related to lock service time. Lock service time is defined as the elapsed time from when the stem of a down bound ship passes the upstream Limit of Approach Light No. 2, is locked through, and the stern passes the downstream Limit of Approach Light No. 2 (Figure 5-1).

Optimum lock service time (and the resulting optimum lock throughput) is dependent upon the timing of vessel arrivals, and the characteristics of the vessels using the system. When the vessel arrival rate exceeds the capability of the locks, queues form. As the vessel arrival rate increases, waiting time in the queue increases exponentially for a constant lock service time. Similarly, as lock service time increases due to slower or larger and more cumbersome vessels transitting the lock and the vessel arrival rate is constant, waiting time in the queue also increases exponentially. Dynamics of these relationships are shown in Figure 5-2 and are based on data in Reference 10.

These data also indicate that the vessel arrival pattern at the locks follows a Poisson distribution and that the lock service time approximates a second order Erlang distribution. Hence, the application of the conventional single waiting line, one station, Poisson arrival and Erlang service queue analysis is valid for the analysis of lock throughput.

The theoretical analysis shown in Figure 5-2 indicates that for a forty-five minute lock service time, such as that experienced

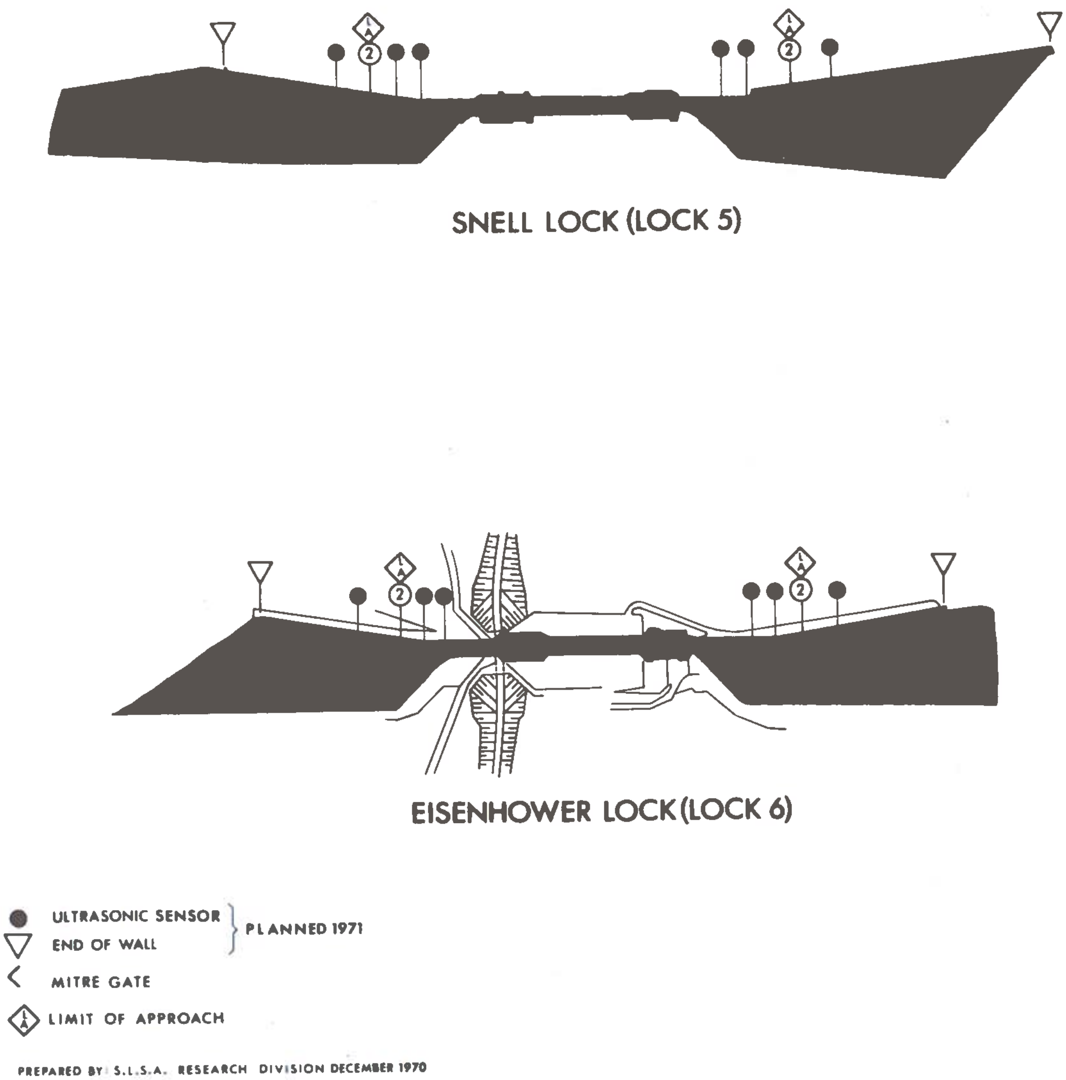


Figure 5-1 Lock Diagram-Snell and Eisenhower Locks

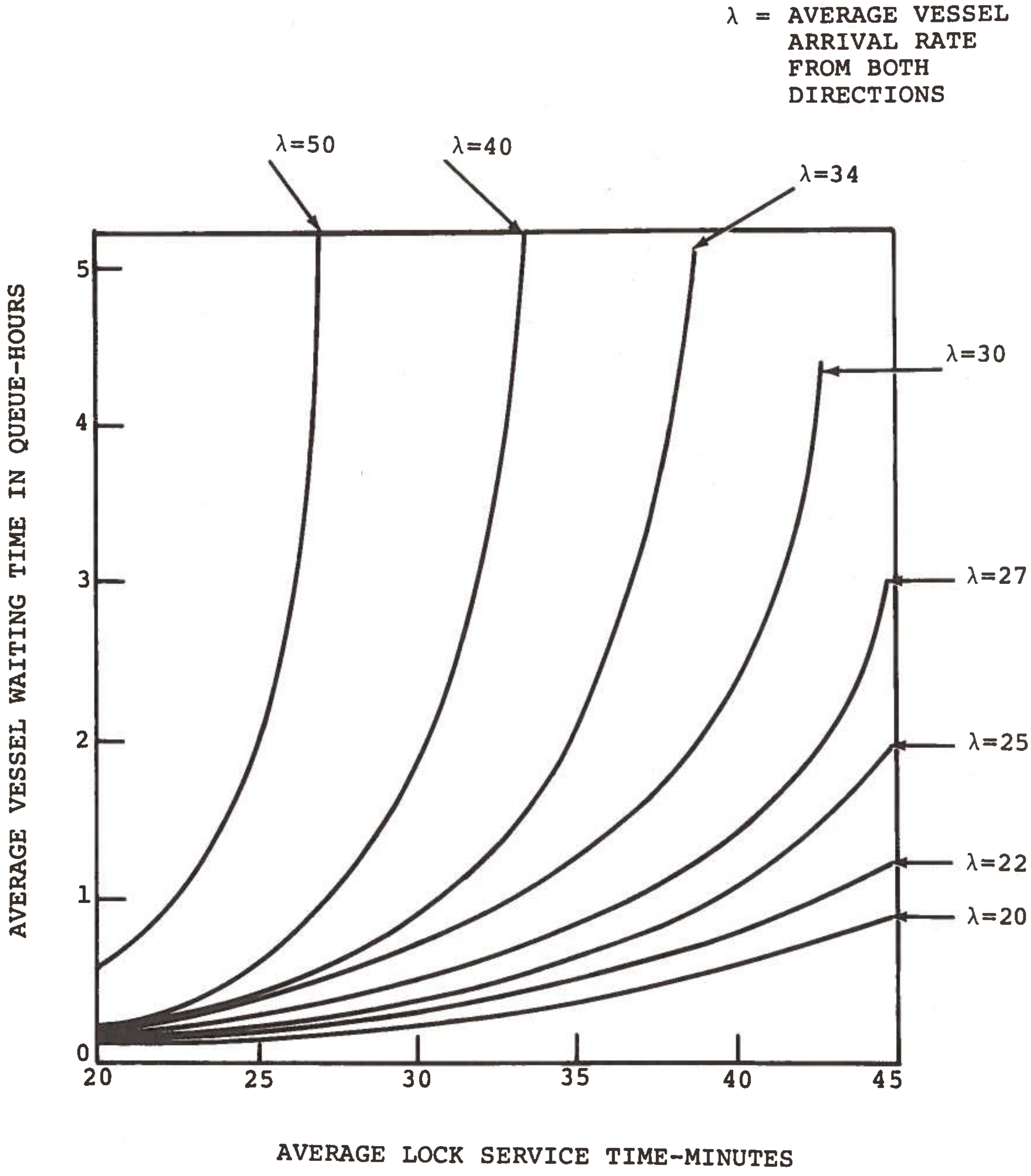


Figure 5-2 Vessel Waiting Time Vs. Lock Service Time

at Beauharnois, slightly over twenty-two ships can be processed through the lock in a 24 hour period. Each ship will spend over one hour in the queue. Based on empirical data, the nominal throughput is twenty-three ships per day. For certain short periods of time a 28-30 ship rate can be achieved; however, this rate can be achieved under degraded safety conditions and cannot be sustained reliably.

The vessel mix in the time frame of this study will continue to consist of a broad spectrum of ship classes, ages and characteristics although the trend will be toward longer ships with greater capacities (Section 4). The inertias associated with these larger vessels will cause longer lock service times, however, their larger capacities will be reflected in greater system tonnage throughput.

The mix of the ships which use the system also affects lock service time. Current policy is to accept the ships at the locks on a first come--first served basis, rather than patterning the ships to optimally match the characteristics of both the ships and the locks. For example, small ships, or a small and a large ship, can be placed together in a single lock (tandem lockages) provided they arrive at the lock at, or close to, the same time. The actual arrivals are not coincident with the optimum theoretical patterning and hence improvement in throughput is often subservient to customer relations. The users of the system represent a mix of ships of varying sizes, performance characteristics and capabilities which must be accommodated.

5.3 TONNAGE THROUGHPUT

The theoretical capacity of the Seaway system expressed as tonnage throughput was determined in Reference 8. In this study, the bottleneck locks of the Montreal-Lake Ontario section (Beauharnois) and the Welland Canal section (Lock 7) were the major systems constraints. For these constraints (locks), a transit plus waiting time of 220 minutes was determined to be indifferent for any increasing vessel arrival rate. This figure was used as the allowable average vessel transit plus waiting time. A figure of 300 minutes was used as an acceptable upper limit. These bounds were used to determine the maximum vessel arrival rate which could be handled by the system. Various operating strategies (synchronous and asynchronous lock operations) were postulated for the Beauharnois Locks. Using the predicted average tons per vessel in a specific year (Section 4) and various load factors to adjust for ships transitting the system in ballast, the theoretical yearly system capacity was determined. The results of this determination are shown in Table 5-1. These data predict the capacity of the system for various years in the period 1970 to 1980 provided that the system is optimally loaded at all times. As can be seen from this table, theoretical system capacity is greater than 100 million tons for the Montreal-Lake Ontario section under the assumed operating conditions. Similarily for the Welland section, theoretical system capacity approximates

TABLE 5-1. SYSTEM CAPACITY IN MILLION TONS

LOCKS	OPERATING MODE	ALLOWED VESSEL TRANSIT TIME	1970	1972	1974	1976	1978	1980
BEAUHARNOIS	ASYN, MODE	300 min.	105.4	102.8		110.3	115.6	117.5
		220 min.	101.7	95.0		105.3	103.5	107.5
	SYN. MODE	300 min.	82.1	88.9	92.2	91.1	95.2	96.0
		220 min.	77.4	81.4	84.0	85.1	88.1	88.8
WELLAND LOCK 7		300 min.	87.9	89.4	89.6	95.1	98.8	101.5
		220 min.	83.5	85.8	86.4	90.6	94.2	91.8

95 million tons.

5.4 THEORETICAL MAXIMUM vs. PRACTICAL LIMITS

If an optimum vessel arrival rate could be maintained over the operating season of the system, then the Seaway could yield capacities of 100 million tons or more. In actuality, the vessel arrival rate fluctuates drastically throughout the season, and generally follows a Poisson Distribution. Figure 5-3 shows an actual vs. calculated plot of the vessel arrivals in an eight hour period for the months May through September 1971 for Lock 1 of the Welland Canal. This distribution is typical of that experienced throughout the Seaway system during the operating season. This curve was derived from Reference 9.

The distribution shown in the figure indicates that there is a sharp peak in the daily arrival rate. This peak causes congestion, queues and the resulting transit delays. Under current operating strategies, vessel arrival rates occur in a random manner making traffic peaks and the resulting queues inevitable. If the peaks in the arrival rate can be diminished such that vessels can arrive in equal time intervals, then queues and delays can be reduced and system throughput can be increased.

A typical plot of the vessel transits against time shows a similar distribution although it is slightly skewed to the right in favor of increased transit time. Figure 5-4 shows this distribution for upbound traffic for the Montreal-Lake Ontario traffic for a portion of the 1968 season. The one sigma distribution is from 16 to 25 hours. Outside the standard deviation, transit times have been as high as 46 hours. This period of increased transit time shows the effects of service interruptions including operational delays due to weather, pilotage and accidents and increased traffic such as that which appear at the beginning and the end of the Seaway season. Historical data have indicated that between 10 and 15 percent of the time, service interruptions occur. When service is interrupted, vessels commence to stack up and queues begin to form. The inevitable result is that the peak rate of arrival begins to exceed the system capacity at the locks.

The control of vessel arrival rates such that they assume a uniform pattern can be achieved through the use of traffic control and associated planning functions and algorithms. Such a system can be used not only to position the vessels to create a uniform arrival rate, but also to control the mix of vessels to exploit the characteristics and capacities of the locks and reaches. Through the use of such a traffic control system, throughput can be increased so as to approach the theoretical capacities of the system. A traffic control and planning system is warranted even at the current 10% of the time when the system is saturated since the annual savings in time and dollars exceed initial system investment. Further discussion of these savings is covered in Section 9, System Improvements and Benefits.

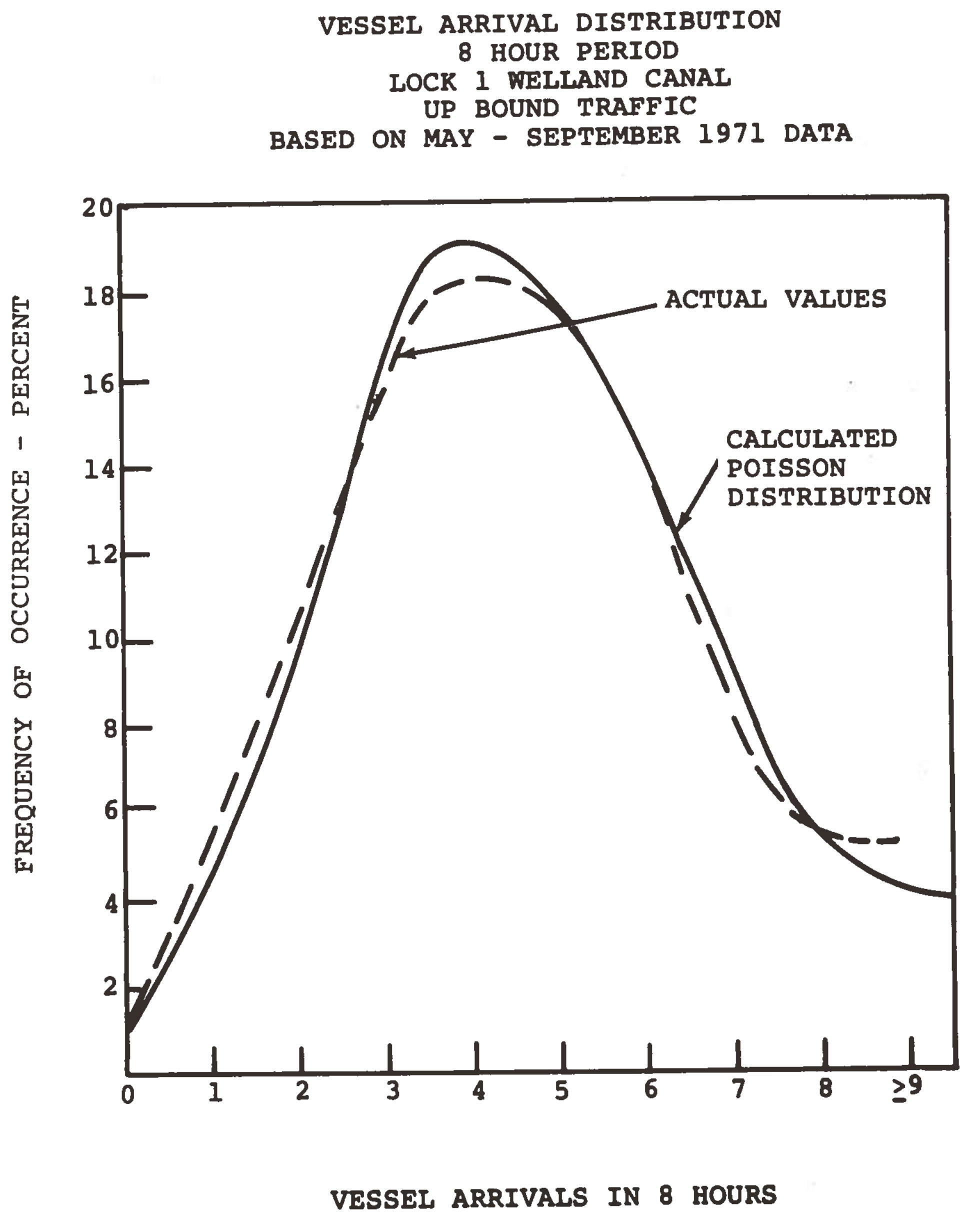


Figure 5-3 Vessel Arrival Distribution

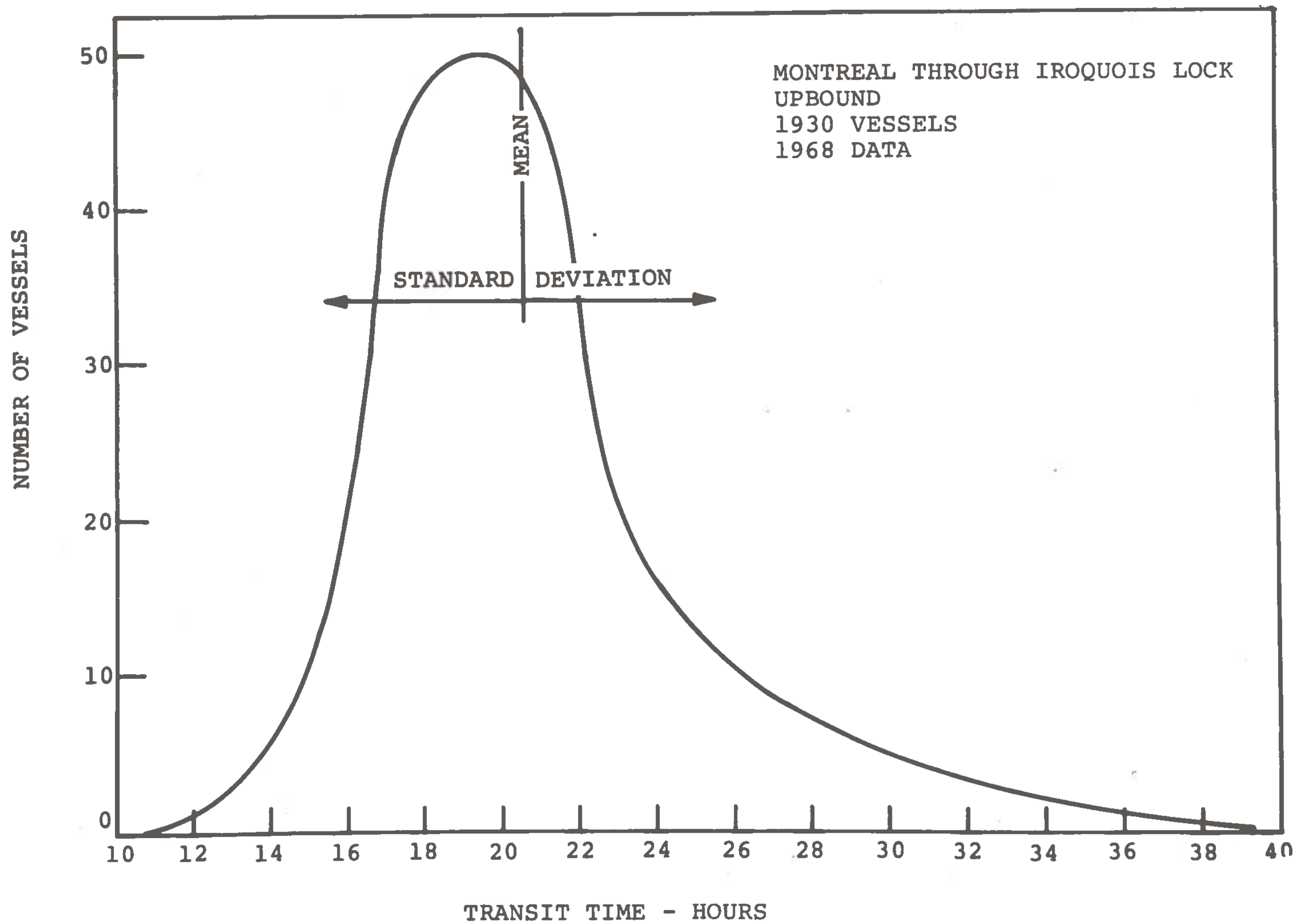


Figure 5-4 Transit Time Distribution

5.5 SYSTEMS SERVICE CAPABILITY

Systems service capability is measured in ton-miles and reflects the actual and projected performance of the Seaway system. Annual performance is determined by the total tonnage, the number of transits and the distance each ton of cargo moves on the section of waterway. Figure 5-5 shows the system service capability of the Montreal-Lake Ontario section of the St. Lawrence Seaway from the start of operations in 1959 through its projected growth into the 1990 period. If 100 million tons is the maximum tonnage capacity of the system and in 1990 the total number of transits are 6550, then the Seaway is capacity limited to 119 x 10^{12} ton-miles.

The following conclusions can be drawn from Figure 5-5:

- System service capability has doubled since the start of operations in 1959.
- Since 1966 system service capability has plateaued at a level of 62 x 10^{12} ton-miles, and 78 x 10^{12} ton-miles is probably the system ceiling for current system elements.
- Approximately seven years are required for system operations to adjust changes in two or more system elements; viz, the St. Lawrence Seaway commenced operations in 1959 and peaked in 1966. The system elements which were changed were ship size and waterways depth and width.
- Demand projections indicate growth in Seaway traffic. However, to progress from the projected system ceiling of the 1976-1980 period to the ultimate Seaway capacity as constrained by the locks, development programs for second generation improvements in system elements must be initiated now to meet the demands of the 1980-1990 period.

Figure 5-6 shows the system service capability for the Welland section from the opening of the Montreal-Lake Ontario section to the post - 1990 period. Using the data in Table 5-1, assuming the 95 million tons is the system capacity, then the system service capacity is limited to 19.0 x 10^{12} ton-miles.

The following conclusions can be drawn with respect to the Welland section:

- System service capability has more than doubled since the opening of the Montreal-Lake Ontario section.
- Since 1966, system service capability has plateaued at a level of 11 x 10^{12} ton-miles. System ceiling is probably 14 x 10^{12} ton-miles.
- The full impact of centralizing the Welland Canal traffic control element at St. Catharines in 1967 and extending

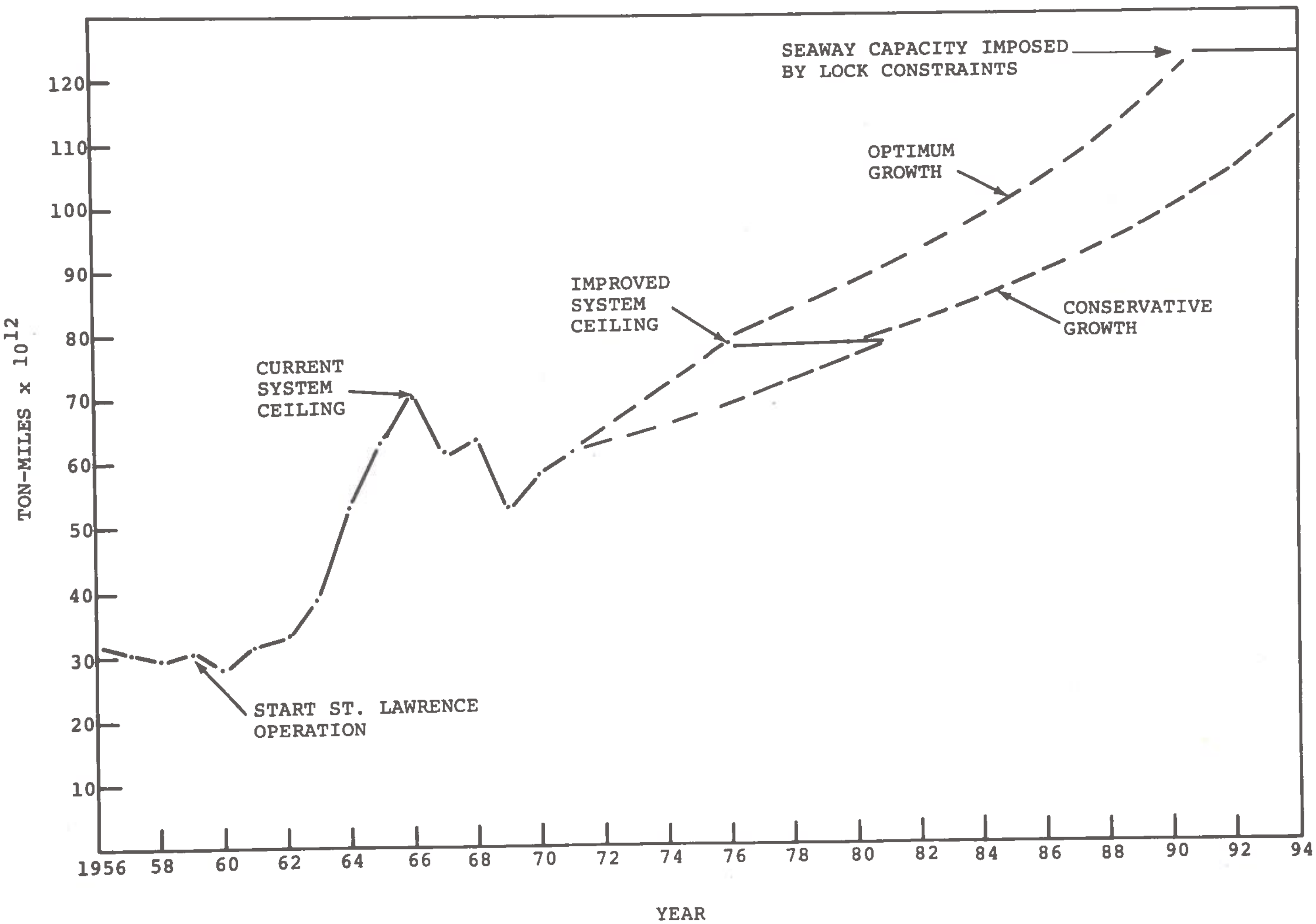


Figure 5-5 Montreal-Lake Ontario Section System Service Capability

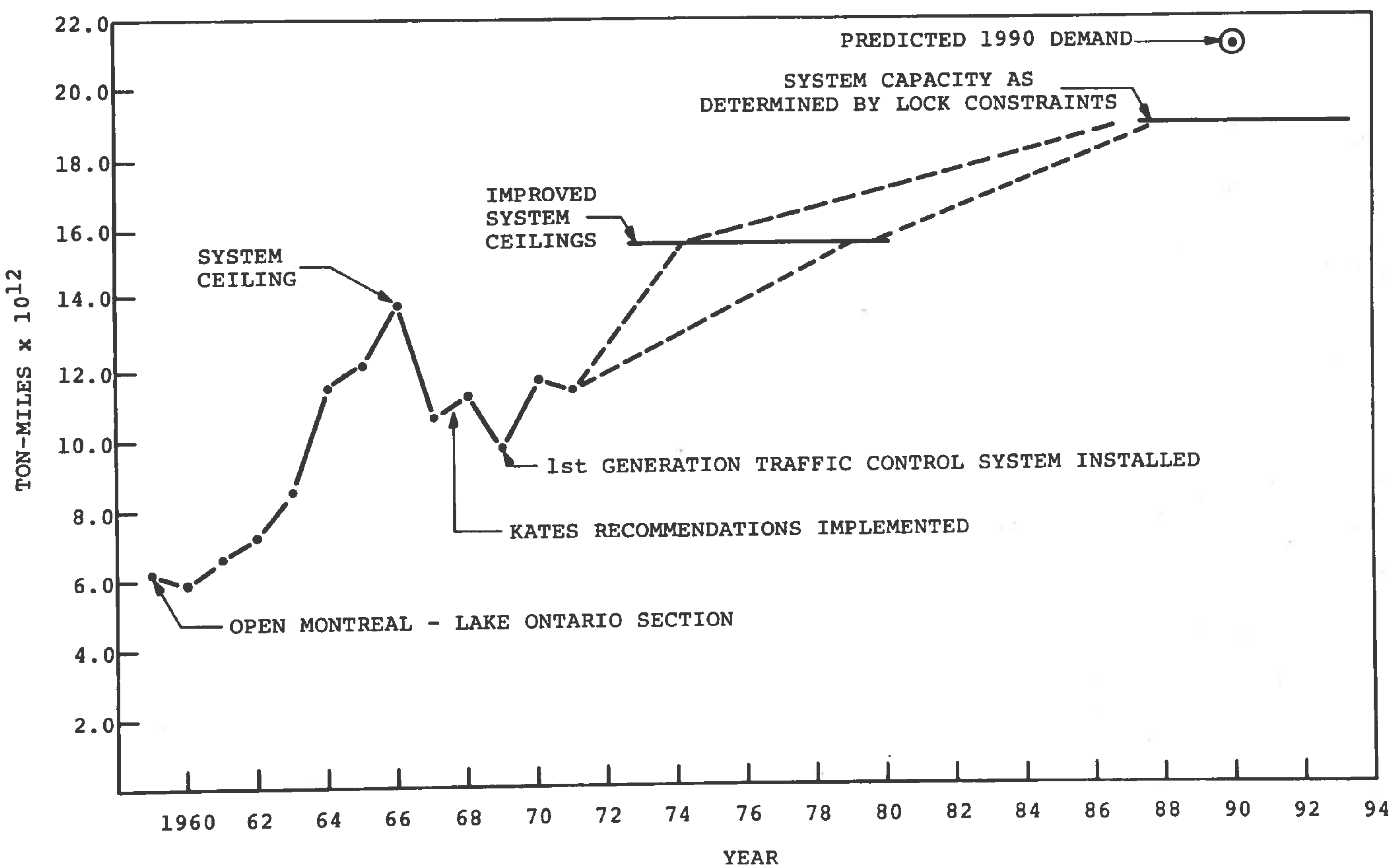


Figure 5-6 Welland Section System Service Capability

Welland control into Lakes Ontario and Erie in 1970 will probably not be completely felt until the 1974-1978 period; the impact of the Kates recommendations in the 1972-1976 period. It is estimated that these improvements will add 15 percent to the system ceiling.

- Projections for 1990 indicate a level of demand of 21.2 x 10^{12} ton-miles; system capacity cannot meet this demand under current lock configurations and current (1971) traffic control element improvements. To achieve at least the capacity determined by the lock constraints, the 1974-1978 system ceiling will have to be raised to this level by second generation improvements in the system elements.

6.0 SYSTEM TRANSIT TIME AND DELAYS

6.1 VESSEL TRANSIT TIME

In 1971 the typical 730 foot lake vessel made twenty-six round trips through the St. Lawrence system. The vessel on-loaded wheat at Lake Superior ports, off-loaded it at Montreal or Quebec; from there it continued on to Sept Iles at the mouth of the St. Lawrence River. At Sept Iles it on-loaded Labrador iron ore and backhauled it to Hamilton, Ontario or Erie, Pennsylvania. Nine days were used in transit; 6 to 8 hours each at the four ports to on-load or off-load cargo (total of one day).

The typical ocean liner makes four round trips between Europe and the Great Lakes each year, visiting three lake ports on each trip. 67 percent of the ocean cargo goes to Europe. Generally, the ship visits one port each on Lakes Ontario and Erie and thence on to the Huron-Superior-Michigan Lakes region. The typical general cargo vessel is in the system from 24 to 30 days of which 8 to 10 days are spent in transit time. The 709 foot ocean vessels, specifically optimized for Seaway operations, can make St. Lawrence River-Great Lake round trip in a minimum of fifteen days (Section 3.0).

To determine the savings which could reasonably be achieved in transit times in portions of the Seaway covered by this analysis, theoretical and actual average transit times were derived for the Montreal-Lake Ontario and Welland sections. These times are summarized in Table 6-1 and are the theoretical transit times within the speed capabilities of typical lake and ocean vessels, and within the speed constraints of the Seaway itself.

In the determination of these times, it was assumed that all locks are ready for the approaching vessel and that there is no waiting time or time lost due to operating delays. Maximum speed for the ocean vessel was assumed to be 15 mph while that for the laker was 12 mph.

System speed limits were recognized where applicable. Wind effects were not considered and a constant water current was assumed.

Also shown in Table 6-1 are the theoretical transit times for Montreal-Upper Lake transits. These figures indicate that the optimum one-way transit time for an ocean vessel from Montreal through the Welland Canal is between 40 and 41 hours while for a lake vessel, the transit time varies between 43 and 47 hours. Also shown in Table 6-1 are the average transit times for all vessels in 1969. The differences between average and optimum indicate areas for possible system improvement. In the Montreal-Lake Ontario section for downbound vessels maximum savings approach 1.5 hours, while upbound vessels in this region may achieve a savings of over four hours. In the Welland section the maximum

TABLE 6-1. THEORETICAL AND ACTUAL TRANSIT TIMES

	UPBOUND TIMES - HOURS			DOWNBOUND TIMES - HOURS		
	LAKER	OCEAN	1969 Average (actual)	LAKER	OCEAN	1969 Average (actual)
Montreal-Lake Erie	46:44	41:10	52:53	43:31	40:03	49:05
Montreal-Lake Ontario Section	23:13	20:40	24:56	19:49	19:21	20:58
Welland Canal Section	11:12	10:31	11:58	10:46	10:21	12:01
Montreal-Sault Ste. Marie	-	-	91:00	-	-	87:00
Montreal-Chicago	-	-	108:00	-	-	104:00
Montreal-Duluth			117:00	-	-	114:00

Note: In practical applications, ocean and laker transit times are nearly identical savings which can accrue are approximately 1.5 hours. Overall in the section from Montreal through the Welland Canal and including all of Lake Ontario, transit time reductions downbound could range from six to nine hours, while upbound reductions could approach 12 hours. Additional transit time savings could be achieved by expediting traffic on the Upper Great Lakes as well.

Time lost due to the unavailability of dock space in the St. Lawrence or Great Lakes ports or the lack of, or deficiencies in the scheduling of stevedores is probably the greatest cause of delay for ocean vessels. Specific data on 1971 port-turnaround times for every ocean vessel entering the system is being developed. During October-November 1971 period the unavailability of port facilities and/or handling crews due to poor or non-existent scheduling doubled and tripled normal Seaway delays.

During a typical 1971 fall season ocean vessel transit, 14 to 22 days were spent in port or waiting for port facilities. The actual time spent in loading and unloading rarely exceeded two days in each port. The remaining time periods represent areas where substantial savings may be made. Most of the in-port delays were caused by inadequate planning of resources and facilities. These inadequacies were reflected in empty berths in one port, while adjacent ports were saturated and vessels were waiting at anchor outside the harbor. Outbound cargoes often inhibited unloading inbound cargoes because the outbound cargo overflowed the terminals to such an extent that rail embargoes were imposed. Similarly, cargo handling crews were inefficiently scheduled. These events caused needless delays and subsequent overtime work conditions.

Figure 6-1 shows graphically the comparative relationship of transit and in-port time between lake and ocean vessels. Specifically, it indicates the areas wherein time savings can be accomplished. If system element improvements such as traffic control and information management can effect, for example, a 12 percent savings in transit time, then this results in a one-day savings per round trip for both lake and ocean vessels. If a similar 12 percent savings in port operation time can be achieved, then the savings for lake vessels is three hours, while for ocean vessels the savings could mean two to three days.

The transit histories of a representative sample (10 percent of 1970 transits) of ocean liners and Marus were examined to determine traffic patterns and time distribution (Appendix A). The results are shown in Figure 6-2 for transits to Lake Ontario, Lake Erie and the Upper Lakes. In Lake Ontario, times are evenly divided between in-port plus waiting and underway. Ocean vessels with destinations in Lake Ontario usually enter only one port. In Lake Erie and the Upper Lakes the in-port, waiting and interport times exceed the transit times by a factor of two. These preliminary data substantiate the fact that a significant portion of the ocean vessel time is unproductive (idle in port or waiting to enter port). A detailed analysis is necessary to fully determine the extent of the potential savings.

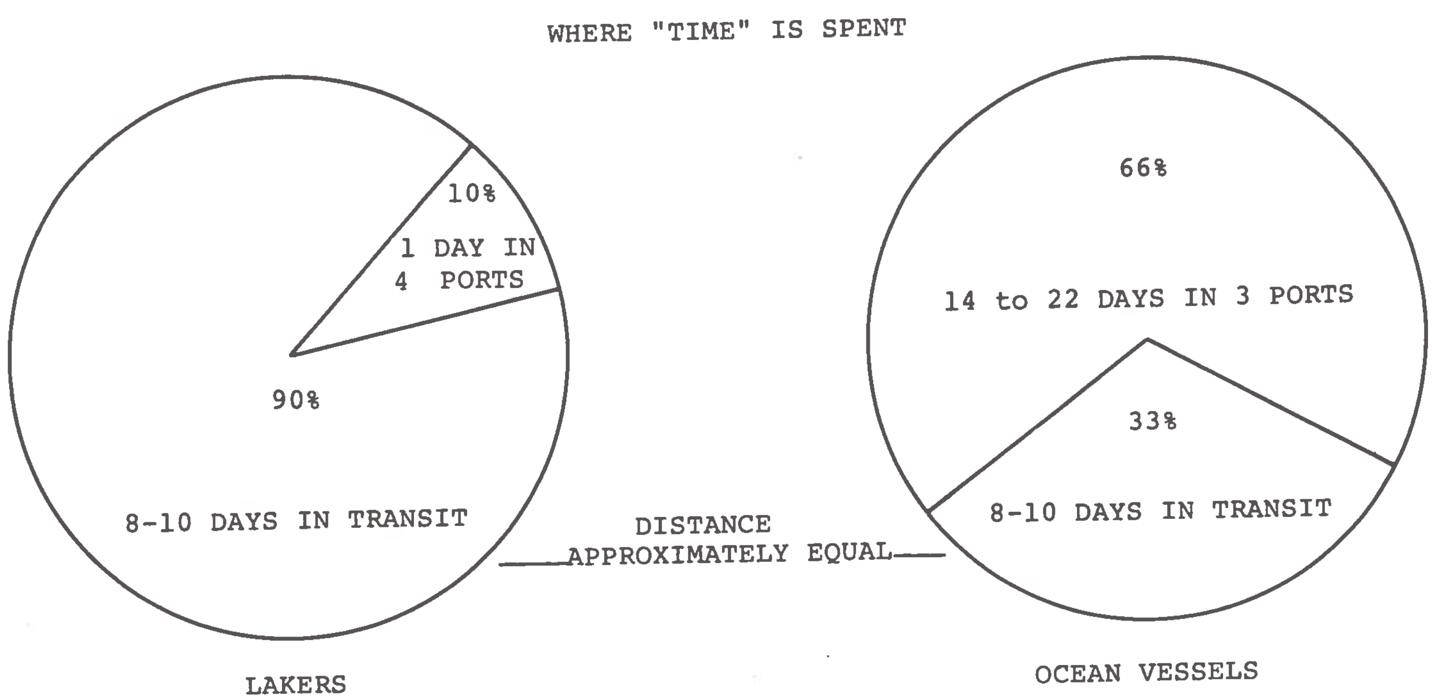


Figure 6-1. Where "Time" is Spent

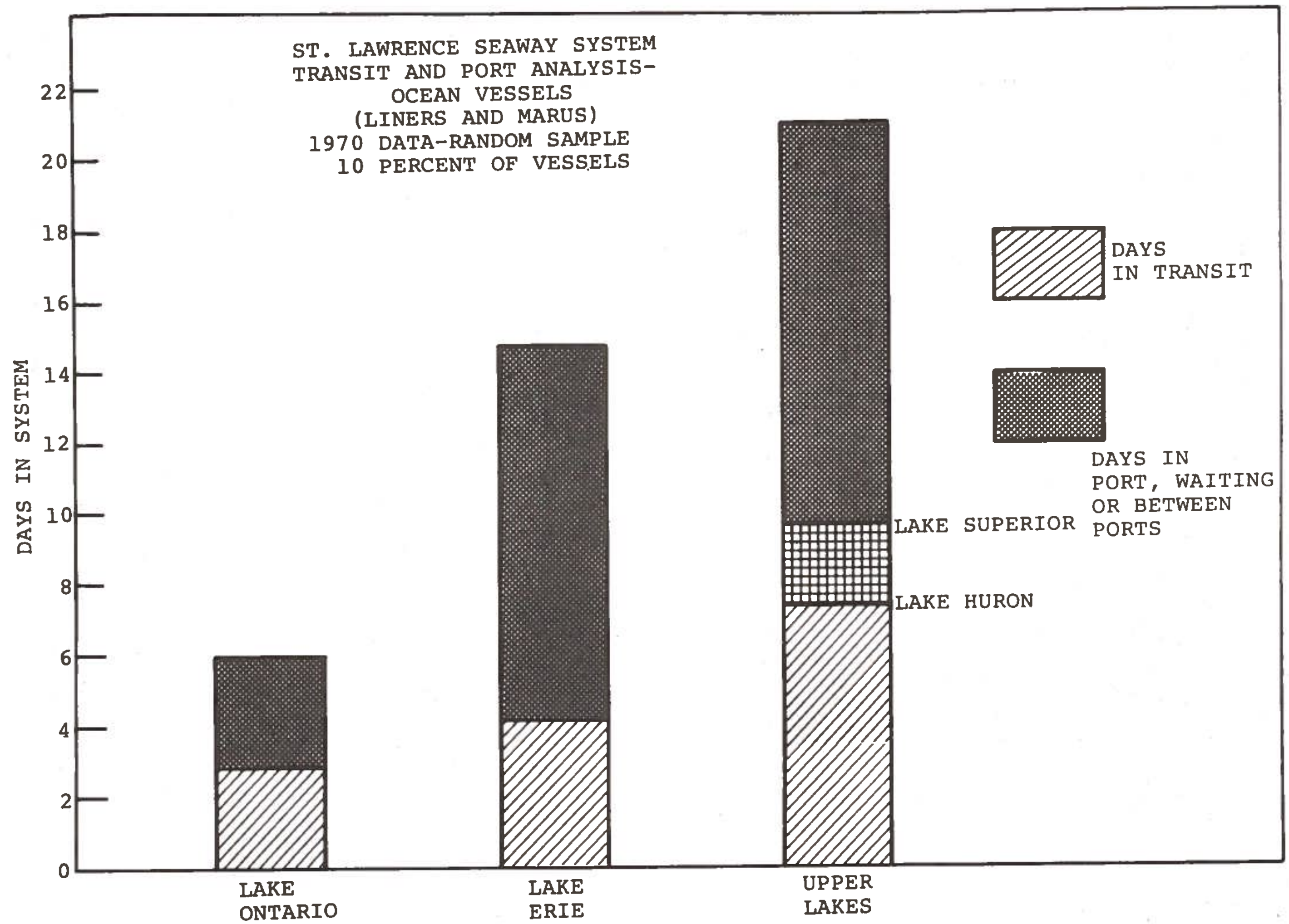


Figure 6-2. Transit and Port Analysis

6.2 TRANSIT DELAYS

Transit delays affect system performance by causing full or partial system shutdowns. These delays are grouped principally into four categories: weather, vessels, structures, and pilotage. Weather includes system shutdowns due to low visibility, and wind. The vessel category reflects closures due to vessel breakdowns, fires, groundings, collisions, etc. Structures consists of system down time due to failure of the bridges, locks, etc. Pilot delay reflects system closure due to the unavailability of pilots, due to inclement weather and/or due to poor planning or scheduling. Table 6-2 summarizes these data for the period 1968-1971 for the Montreal-Lake Ontario section. Additionally, these data are subdivided by U.S. and Canadian entities. The table indicates the the total lost-time vessel hours. The St. Lawrence Seaway Authority will complete its data reduction and analysis activities during the summer of 1972.

Table 6-2 partially indicates the vessel hours lost due to system shutdown. Incomplete data for the Canadian portion of the Montreal-Lake Ontario section for the years 1968 and 1971 have indicated that 12,026 and 13,391 vessel-hours have been lost respectively for the two years indicated. The principal cause for lost time hours is weather, accounting for nearly 90 percent of the losses.

In the Welland section, the navigational delays due to system closure are shown in Table 6-3, for the period 1968-1970. The data for 1971 are incomplete at present. However, data are available for vessel lost time hours for 1971. Total lost productive time was 25,794 vessel hours. Of this total, 22,942 vessel hours or nearly 90 percent was attributable to the unavailability of pilots.

The above data are incomplete and should be used with caution, however, they do indicate that weather and pilot scheduling are principal problems in daily Seaway operations. These areas could impact substantially on system service capability in the near future.

6.2.1 Weather Problems

Seaway operational instructions require the traffic to be slowed down whenever the visibility is less than 3,000 feet and to anchor at 900 feet. Steam fogs caused by water vapors on icy days are the principal cause of low visibility. Though radar reflective navigation aids are on hand, most ocean vessels are not equipped with river radar of high resolution capability and therefore cannot efficiently operate even at 3,000 feet visibility. Buried radio frequency transmitting cable concepts which give locational information within three feet have been employed successfully in canals but frequently the cabling is cut by the passing screws of over-draft-limit ships. Infrared and wind fog-dissipating machines have also proven unsuccessful.

TABLE 6-2 SEAWAY CLOSED TO NAVIGATION - ST. LAWRENCE SECTION

HOURS

YEAR	1968			1969			1970			1971		
ITEM	CAN.	U.S.	S/T	CAN.	U.S.	S/T	CAN.	U.S.	S/T	CAN.	U.S.	S/T
VESSEL	70	44	114	41	130	171	75	34	109		42	
WEATHER	244	113	357	494	213	707	736	183	919		360	
STRUCTURES	81			53	20	73	51	38	89		48	
PILOTAGE	6	32	119	9	17	26	8	--	8		7	
TOTAL	401	189	590	597	130	727	870	288	1158		457	

VESSEL LOST TIME HOURS - ST. LAWRENCE SECTION

YEAR	1968				1969				1970				1971			
ITEM	CAN.	U.S.	S/T	NO. OF VESSELS	CAN.	U.S.	S/T	NO. VES.	CAN.	U.S.	S/T	NO. VES.	CAN.	U.S.	S/T	NO. VES.
VESSEL	DATA NOT REDUCED				DATA NOT REDUCED				DATA NOT REDUCED				928			305
WEATHER													11733			1171
STRUCTURES													724			491
PILOTAGE													6			18
TOTAL	12026												13391			1985

TABLE 6-3 SEAWAY CLOSED TO NAVIGATION - WELLAND SECTION

HOURS

YEAR	1968	1969	1970	1971
ITEM		All - Canada		
VESSEL	93	61	78	
WEATHER	224	180	180	
STRUCTURES	94	91	165	
PILOTAGE	1862	918	407	
TOTAL	2273	1250	830	

VESSEL LOST TIME HOURS - WELLAND SUBSYSTEM

YEAR	1968	1969	1970	1971
ITEM	DATA TO BE REDUCED	DATA TO BE REDUCED	DATA TO BE REDUCED	
VESSEL				451
WEATHER				1247*
STRUCTURES				1154**
PILOTAGE				22942
TOTAL				25794

WELLAND DETAILS - 1971

	UPBOUND			DOWNBOUND		
	VESSEL	AVG HR.	TIME MIN.	VESSEL	AVG HR.	TIME MIN.
WIND	11	10	15	15	16	19
FOG	15	14	58	49	13	21
MECH.	4	24	19	4	8	20
OTHER	28	32	33	15	7	28
PILOT.	529	24	43	239	41	17

*WIND 368; FOG 879
** MECH. 131; OTHER 1023

Another major problem are the winds on the high sail (freeboard) areas of ocean vessels and in-ballast lakers. Generally loaded lakers can operate in winds up to 23-25 knots while ocean vessels cannot operate beyond 10-15 knot winds in the Welland section where westerly winds blow from abeam. In the St. Lawrence River, 12-18 knot winds are the upper limits where the winds blow from ahead or astern.

These weather problems indicate the requirement for positive vessel location and tracking capability to permit operations in periods of reduced visibility or marginal conditions.

6.2.2 Pilotage Problem

The pilot pool size is predicted on the previous years total and average daily transit rate (Table 6-4). Peak loadings occur every year in the spring and fall and because of weather, lack of port terminal facilities, equipment failures, accidents, and inefficient scheduling. Often pilots were held on the vessel by weather conditions or lack of adequate pilot boats or until relieved. Vessels which do release pilots often experience difficulties in obtaining pilot replacements when ready to move on.

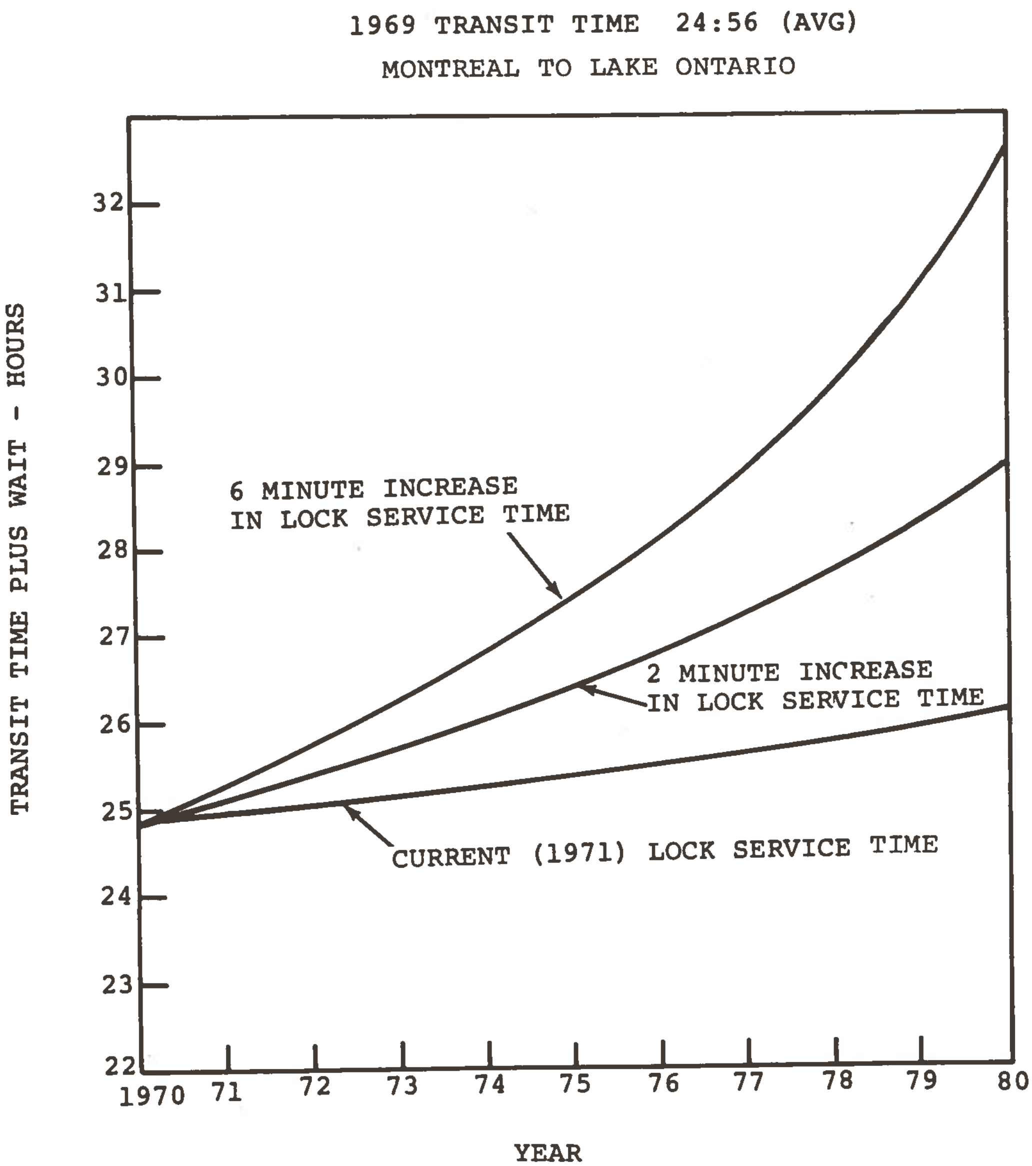
During the August through early November 1971 period, the Welland Canal was a primary pilotage bottleneck. It gradually shifted to the Lake Erie and Port Huron reaches until late November, the bottleneck then shifted back to Welland, and following the winter exodus, to the St. Lawrence section. The lost time due to pilotage delays in the Welland Canal section is substantial (Table 6-3). Additional delays are encountered in Districts 2 and 3 (Lakes Erie, Huron and Upper Lakes). These delays have not been included in the table.

Improved pilot and vessel scheduling is necessary in order to efficiently allocate limited pilotage services during periods of peak demand. Optimum pilot scheduling can be achieved through a traffic control and management information system and by providing all weather pilot boat service. In addition, integrated pilot scheduling is necessary, not only in the Welland and St. Lawrence sections, but in the Upper Lakes as well.

6.3 TRAFFIC DELAYS

In addition to the transit delays which affect the passage of a ship through the Great Lakes-Seaway, the ship will also encounter delays due to traffic. These traffic-caused delays are principally attributable to the arrival rate of vessels exceeding the lock service time and the handling characteristics of the vessels (acceleration and deceleration) causing longer lock service times.

Projected traffic delays for the 10 year period 1970-1980 are shown in Figure 6-3 for the Montreal-Lake Ontario section. The data in this figure are derived from the projections in Section 9, the methodology suggested in reference 10, and the data in Figure 5-1.



FORECAST TON PER LOCKAGE

1974	10,000
1976	10,420
1978	11,083
1980	11,666

Figure 6-3. Projected Increase in Transit Time

TABLE 6-4 PILOTAGE DATA

DISTRICT	LOCATION	NOMINAL TRANSIT TIME (HOURS)	PILOTS			TRIP CAPACITY PER WEEK			
						NOV.		DEC.	
			CANADIAN	U.S.	TOTAL	MIN.	MAX.	MIN.	MAX.
Cornwall	Montreal-Snell	12	38	0	38	95	98	92	93
No. 1	Snell to Cape Vincent	10	18	13	31	93	124	Same	
	Lake Ontario	12	7	7	14	42	56	Same	
No. 2	C.I.P. 15 To Lock 7 (Welland Section) Lock 7 to	12	30	0	30	91	106	Same	
	Port Huron (Lake Erie)	13	12	33	45	135	180	Same	
No. 3	All Lakes Above Huron	8	25	33	58	Nominal			

These curves forecast the average time required for a vessel to transit this section based upon varying lock service parameters and upon projected increases in annual tons per lockage. The Beauharnois Locks are initially assumed to require 40 minutes per lockage while the remaining locks 33 minutes. Assuming that these lock service times can be maintained in the 1972-1980 period, the increase in transit times is shown in the lowest curve. The intermediate curve is based on the assumption that Locks 1,2,5,6,and 7 will require an average of 33 minutes in 1972-1973; 34 minutes in 1974-1977 and 35 minutes in 1978-1980. In a similar period, the Beauharnois Locks (Locks 3, 4) will require 40, 42 and 44 minutes respectively. Under these assumptions, by 1980 average transit times will have risen to 29 hours. These increases in lock service time are based upon the assumption that longer, deeper draft vessels will require additional time to transit each lock of the system.

The Kates Report, Reference 3 cites an increase of seven minutes in lock service time for each additional 100 feet of vessel length over 500 feet. Figure 4-10 indicates at least an 85 foot growth in vessel length by 1981. Based on these data, an increase of six minutes in lock service time is assumed in the 1971-1980 period. These lock service times are:

Locks	1971-72	1973-77	1978-80
1,2,5,6,7	33	36	39
3,4	40	43	46

The upper curve indicates the result of these increases in lock service times. By 1980 an average of 32.5 hours could be required to transit this section. This represents an increase in average one-way transit time of over 7.5 hours over that currently required (1971), and 12.5 hours over the optimum transit time. These increases represent 45,000 and 75,000 vessel hours respectively in 1980. In addition, these curves indicate graphically one of the basic planning factors for Seaway operations viz: One additional minute of lock service time equals one additional hour of Seaway transit time.

Similar data for the Welland Canal have not been determined, however if tonnage and shipping trends follow the projections in this report and no further canal improvements are made, it is estimated that transit times will increase from the current 12 hours to 17-18 hours in 1980 and will reach 20 hours by 1990 (Reference 3). Thus a 5-6 hour delay could be expected in 1980 and increase to 8 hours by 1990. Translated into vessel hours, these delays for the 1980 period are estimated at 38,500 vessel hours and 56,000 for 1990.

6.4 UNIT COST of DELAYS

6.4.1 Direct Costs

The cost of operating a vessel has been variously estimated at $150-$200 per hour (References 3, 13). This figure reflects daily routine operations at sea and includes the operation and maintenance costs. Depreciation costs of the vessel and return on investment to the shipowner are not included. When a ship is operating in confined waters such as the Seaway, additional operating personnel are required (e.g., line handlers, extra engine room personnel) which could cause costs to approach $250 per hour. In this study $200 per hour will be used in the cost comparisons throughout the time period under consideration. Pilotage at $43 per hour is not included ($9000 per trip), as are the effects of inflation, greater productivity and improved efficiency of operations.

6.4.2 Indirect Costs

In addition to the costs of operating a vessel, there are inventory, pipeline and in-port handling costs associated with the value of the commodities. The latter costs result from the uncertainties associated with the transshipment of bulk and general cargo. The former costs reflect the non-productive value of the goods while they are in transit or in inventory and include the cost of borrowing the money to maintain the inventory and the associated administrative costs. Once the pipeline (i.e., the goods in transit or in inventory) from the producer to the user is established, the value of the goods or commodities in this pipeline is maintained at a constant level and does not enter into the cost of Seaway operations.

When the time required to ship the goods or handle the goods is increased, the user must increase the amount of goods in transit in order to maintain the same inventory level. The incremental cost of borrowing in order to maintain the same pipeline level is an indirect cost attributable to delays. This cost is a one-time charge and can be used in the determination of the effect of not only Seaway delays but also improvements in Seaway operations.

The interest cost for the value of goods in the pipeline is based on 6% per year and includes the associated insurance and administrative expenses.

The hourly cost of the in-port cargo handling facilities, including rail cars, trucks, trailers, and containers in about 1¢ per ton of general cargo and 1/2¢ per ton of bulk cargo. The bulk cargo such as coal and ore, requires an open hopper car and therefore the cost is somewhat less. These costs include the cost of rental (or the alternative ownership costs of depreciation and return on investment), storage space (trailer park, siding, etc.), and protection against pilferage. This cost of 1/2¢ to 1¢ per ton is for only the facilities and does not include the inventory cost of goods awaiting transfer to the ships. The extra cost of maintaining the inventory has been included in the general estimates described above.

6.5 PROJECTED DELAY COSTS

In this section the level of service of Seaway operations was assumed to deteriorate over the next two decades. This deterioration was due to the increase in traffic and to changes in vessel mix and characteristics. No operational improvements were assumed to be instituted either in the planning and scheduling of vessel movements or in the optimum allocation of pilotage. The economic impact of reduced level of service was determined in terms of cost to the ship owner, shipper and user. The costs are deliberately quoted on the low side to offset any bias.

The foregoing discussion considers the direct and indirect cost of delays in Seaway operations. As applied to the average trend data for the 1971 season, the direct costs of vessel delays due to the principal delays in the Seaway were:

Weather	$2,340,000
Pilotage	$4,588,000

The delays due to changes in vessel characteristics and to increases in level of traffic through the system were determined in Section 6. The direct annual costs of these delays for the Montreal -Lake Ontario and Welland sections for the 1980 period are estimated at

Annual Direct Cost - 1980

Montreal-Lake Ontario	$9,000,000
Welland	$7,700,100

The indirect cost of transit time delays are less precise and reflect the value of the goods in transit plus the cost to the shipper to acquire additional inventory in order to maintain a constant inventory level. These costs were estimated using actual 1970 cargo value figures and projections of cargo cost and tonnage for 1980 and 1990. The basis for these figures is the cost of an additional day of transit time over the entire shipping season and its effect with respect to total cargo value. These estimates were prepared for only the Montreal-Lake Ontario section and were determined for bulk and general cargo. The results are shown below for one day's delay for 1980 and 1990 projected values.

Indirect Costs - 1 day total system delay

	1980	1990
Bulk cargo	$380,000	$484,000
General cargo	$314,000	$476,000
TOTAL	$694,000	$960,000

7.0 SYSTEM SAFETY

7.1 ACCIDENT RECORD

Vessel/Seaway accident data for the period 1965-1971 were compiled and tabulated using SLSA and SLSDC accident reports. There are substantial problems of terminology and definitions between the two entities. Multiple entries and redundancies exist. However, based on these empirical data, the typical accident profile in 1971 apparently involved turbine driven ocean vessels which entered the Seaway for the first time. These accidents occurred during the hours of sundown and midnight. The crews were multilingual and the ships' electronic and mechanical control and navigation equipment was oriented to ocean operations. This combination of elements contributed to man-machine response times which were not rapid enough for high density traffic or restricted waters such as those encountered in Seaway operations.

Using the accident data available for U.S. and Canadian operations and adjusting terminology differences and redundancies, a cumulative accident record was derived for the period 1965-1971 (Figure 7-1 and Table 7-1). These data indicate the following trends:

- 75 percent of the Canadian accidents involved 413 ocean vessels. U.S. data on vessel types were unavailable in time for this report.
- 41 percent of the accidents are ship hits.
- Ship hits are most likely to occur when approaching the lock wall.
- 27 percent of the accidents are equipment failures.
- The probability of equipment failure is highest between St. Lamberts and Tibbet's Point. Once the vessel enters the Lakes, the probability tapers off.
- 19 percent of the accidents are equipment failures.
- Groundings are most likely to occur in the St. Lawrence section; collisions in the Welland.

These conclusions are preliminary in nature and indicate the need for detailed data and analysis to illuminate the areas in which corrective action can be taken and to define the requirements for improvements in ship and lock equipment, control and navigation equipment and personnel training.

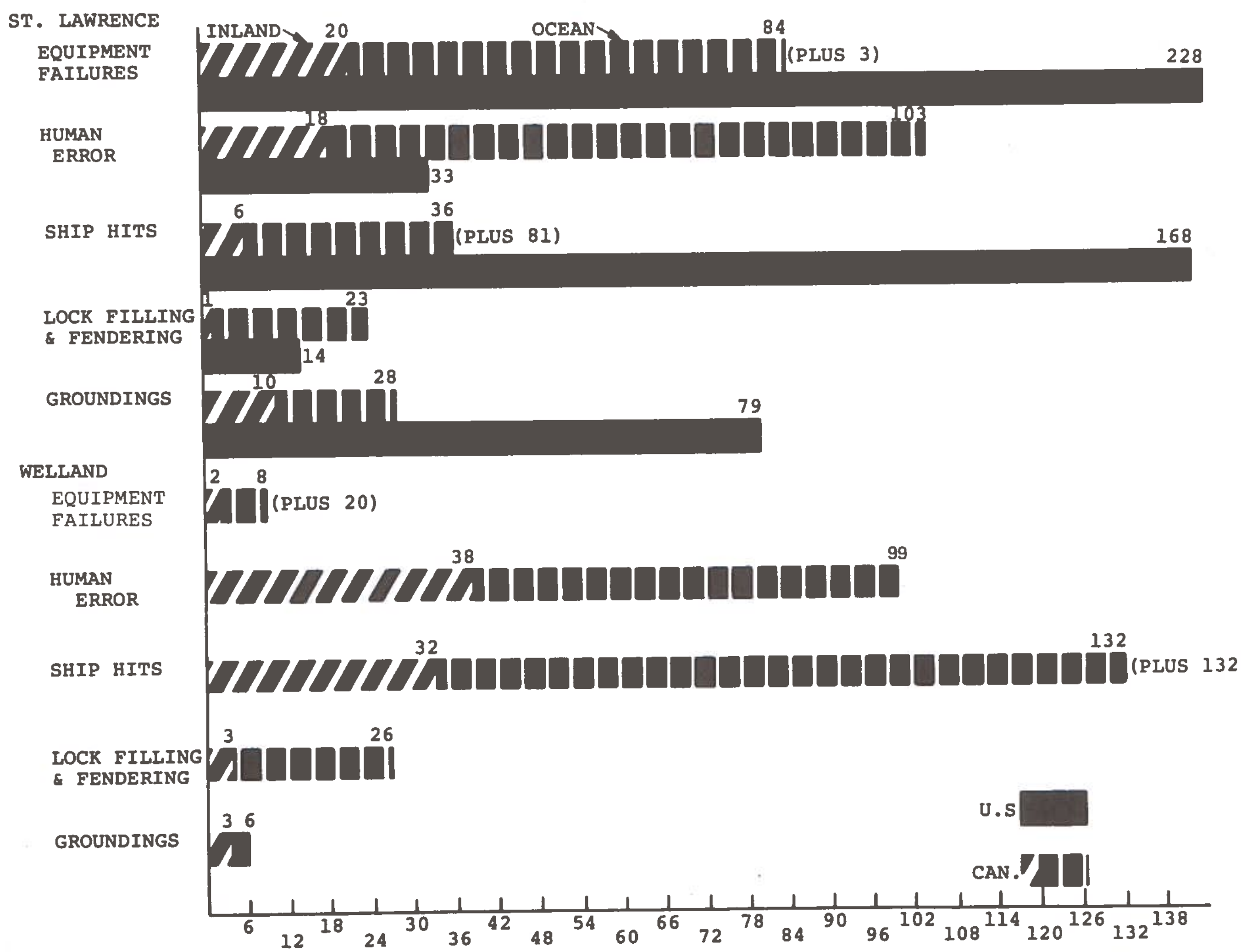


Figure 7-1 Cumulative Accident Record By Vessel Class 1965-1971

TABLE 7-1. 1965-1971 CUMULATIVE ACCIDENT RECORD

	ST LAWRENCE U.S.	ST LAWRENCE CANADIAN	TOTAL	WELLAND	TOTAL
EQUIPMENT	(228)	(84)	(312)	(8)	(320)
SHIP					
STEERING GEAR	34	17	51	4	55
ENGINES	186	65	251	2	253
ANCHORS	8	-	8	-	8
OTHER	-	1	1	-	1
LOCK	-	1	1	2	3
SHIP HITS	(168)	(36)	(204)	(132)	(336)
LOCKS					
WALLS	161	20	181	55	236
GATES	-	9	9	22	31
ARRESTORS	-	4	4	18	22
SILLS/BULLNOSE	5	1	6	2	8
BRIDGES	-	2	2	9	11
PIERS	-	-	-	1	1
BANKS	-	-	-	25	25
BUOYS	2	-	2	-	2
LOCK	(14)	(23)	(37)	(26)	(63)
FILLING	-	16	16	26	42
FENDERING	14	7	21	-	21
SHIPS	(183)	(28)	(211)	(6)	(217)
GROUNDED	79	28	107	6	113
DAMAGED	104	-	104	-	104
WEATHER	-	(1)	(1)	(2)	(3)
HUMAN ERROR	(33)	(103)	(136)	(99)	(235)
SHIP HITS	-	81	81	51	132
LOCK EQUIPMENT	-	3	3	9	12
COLLISIONS	22	15	37	35	72
OTHER	-	4	4	4	8
PERSONAL INJURY	11	-	11	-	11
TOTALS	626*	275	901	273	1174

*U.S. Data Includes Multiple Entries in Each Category

7.2 ACCIDENT FREQUENCY

Figure 7-2 shows the system service capability in ton-miles for the Montreal-Lake Ontario section for the period 1960-1971 and projected through 1976. Also shown in this figure is the U.S. and Canadian accident experience through 1971. Through 1965 the U.S. sector accident experience was apparently proportional to the ton-miles carried through the system. Then a number of interacting events occurred: in the U.S. Sector the River flow characteristics changed due to the installation of a dike in 1963 and the extension of the Snell Lock by 1965. During the same period a bell alarm system was installed on each lock in the U.S. Sector to alert the lock master whenever the lock was hit hard.

In addition, at this time, larger ships entered the Seaway fleet and new pilots and laker captains were added to the fleet staff. These events caused the U.S. accident frequency to double by 1966. In 1967, the Canadians installed visual plot boards and centralized traffic control at Beauharnois and instituted new traffic control procedures on the Canadian sector of the St. Lawrence River. The Canadian accident frequency dipped. The U.S. adopted similar techniques and procedures in mid-1968; also, the bell alarm system was revised so as to require higher impacts to initiate the alarm. As the pilots and masters gained operating experience with the new wall approaches and River characteristics, the slope of the U.S. accident experience returned to parallel that of the Canadians.

The Welland Section accident experience is shown in Figure 7-3. The 1965-1967 accident frequency for this section was similar to that of the Montreal-Lake Ontario section. In late 1967 the semi-automated traffic control system for the canal was placed in operation with obvious results. In 1971 however, the ocean vessel entries increased by 23 percent (including 301 first time entries) and the Welland section accident frequency turned around and increased. The Welland section could not meet the increase in the demand without a degradation in safety.

Since 1967 another trend has developed. There appears to be a direct correlation between the accident rate and the growth rate in average length overall for ocean vessels. Additionally, based on empirical evidence there appears to be some correlation between accidents in each sector, weather and winds, and vessel freeboard (sail area). However, the data are insufficient for positive conclusions at this time.

Data from both the Welland and the Montreal-St. Lawrence sections indicate that as the transit rate increases from 23 to over 28 vessels per day and as this transit rate continues for approximately five to seven days accidents will surely occur. This accident rate will be coincident with the typical spring-winter weather pattern; April, November and December are the worst months.

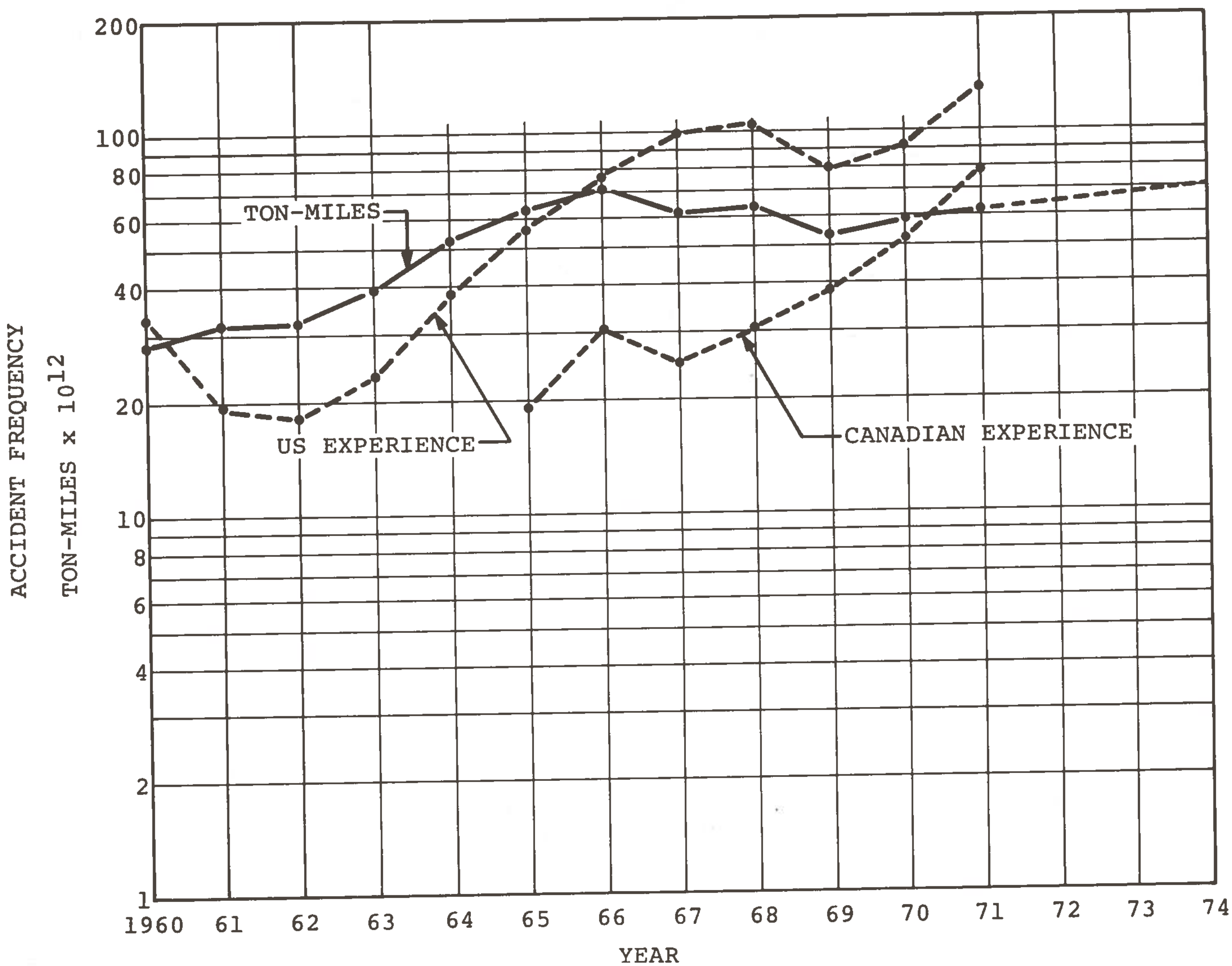


Figure 7-2 Montreal-Lake Ontario Section Ton-Miles and Accident Frequency U.S. and Canadian Experience

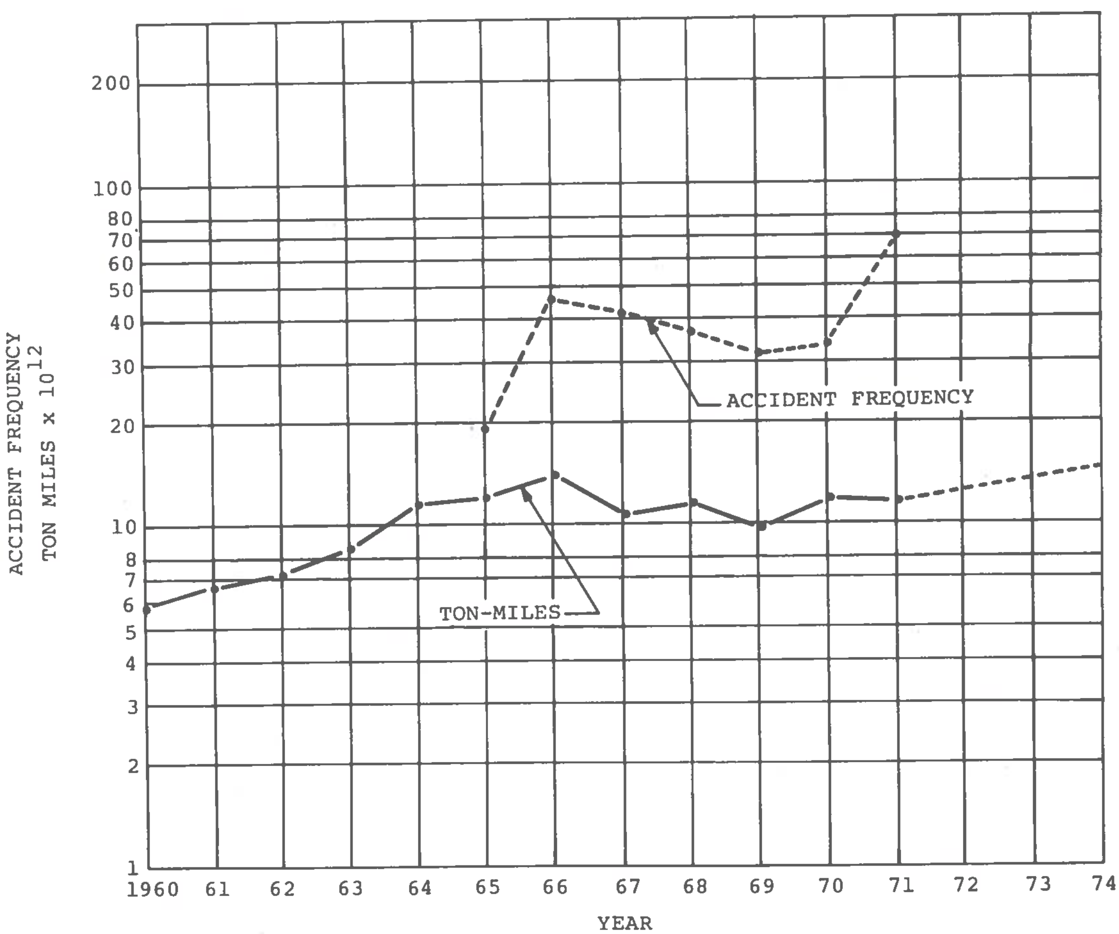


Figure 7-3 Welland Section Ton-Miles and Accident Frequency

7.3 ACCIDENT COSTS

Accidents have been costing the Seaway industry and the Seaway entities over $1,500,000 per year. In some years single accidents alone have exceeded this figure. In 1971, the Singapore Trader went aground in the U.S. Sector. The cost to refloat and repair the ship amounts to over $980,000. The loss to the owners, shippers and insurers is over $3 million. If the costs and frequency of accidents can be reduced, it would more than justify the investment in a traffic control and vessel location system.

Accidents are also reflected in indirect costs. As traffic and vessel transits rise, the accident frequency will climb proportionately. This will result in an increase in the insurance risk and will be accompanied by increased insurance rates. Shipowners, particularly ocean vessel owners, may seek other ports of entry in order to reduce their liability.

8.0 TRAFFIC CONTROL AND MANAGEMENT INFORMATION ELEMENTS - DEFICIENCIES AND REQUIREMENTS

8.1 INTRODUCTION

The foregoing sections have discussed the system elements and how they interact with respect to current and projected operations. These interactions have revealed certain deficiencies now in existence or soon to appear. In the traffic control and management information elements the deficiencies can be principally grouped into two categories: reduction in service to the user and degradation in assured safe operations. These deficiencies and the action necessary to correct them provide the basis for systems requirements.

8.2 IMPROVED SERVICE

8.2.1 Reduction in Queueing

Control of the vessel arrival rate at the locks so as to be in consonance with the lock service time can help reduce the build up of queues and improve throughput. When a slowdown does occur, the system traffic should be controlled in such a way that delays and build-up of queues are kept to a minimum. Due to geography and the characteristics of the facilities and vessels, the Seaway system has a large inertia factor which inhibits effective response to changes in traffic patterns. It currently requires from four to six hours to optimally reposition traffic after it has been disrupted or halted. This fact, coupled with the sensitivity of the level of service to lock service time (variations in lock service time in the order of one minute result in transit time variations of one hour) demonstrates that in order to avoid the build up of queues the Seaway traffic control system should permit scheduling of future operations while adjusting for changes in current schedules.

IMTIC can schedule the vessels at the locks so as to optimize the arrival rates. Such scheduling will permit the arrival of vessels to occur in a uniform, rather than a random manner. IMTIC thus can shorten lock service time by planning optimum vessel entries into the lock (the stern of the outgoing vessel passes the bow of the incoming vessel at the No. 2 Limit of Approach Light; both vessels are underway). Further decreases in lock service time must be accomplished by facility improvements; e.g. hydraulic assist in departures, automated mooring.

8.2.2 Reduced Transit Time

Underway system traffic is often constrained and delayed because slow-moving vessels cause congestion and vessel stack ups astern. This effect is particularly pronounced in restricted areas such as channels and canals where overtakings and passings by faster-moving vessels can not be effected. A frequent situation occurs wherein a vessel transitting the Seaway is aware that berthing and handling facilities will be unavailable at the time of arrival at the destination. This situation happens frequently when the vessel has an ETA at port on a week-end or between stevedore shifts. Except on an emergency basis, cargo handling is not performed on the week-end and arrival in the middle of a stevedore shift requires the payment for a full shift. Hence, the master of a vessel will deliberately reduce his speed through the Seaway as to arrive when the port and handling facilities are ready to receive him at the lowest cost to him.

A traffic control and management information system (IMTIC) can be used to optimally position vessels with respect to their speed characteristics or their anticipated speed of advance so as to permit overtaking by faster moving vessels in passing areas. Secondly, such a system can be used to schedule vessels so as to match speed characteristics with their port arrival requirements.

8.2.3. Improved Lock Utilization

A vessel heading toward an idle lock is often forced to wait or slow down while the lock is recycled in order to receive him. This causes needless delays and extensions in transit time. Traffic control and scheduling will permit the determination, in advance, of when the lock will be ready. Locks can be scheduled, and approaching vessels can be speeded up to take advantage of idle locks.

8.2.4. Improved Availability of Pilotage

Many delays are attributable to the lack of or inefficient scheduling of pilots because of insufficient advance information on vessels leaving ports, transitting the Seaway and arriving at pilotage change points. The centralized coordination and integration of vessel and traffic related information, particularly with respect to pilotage requirements can do much to optimize the allocation of pilots and to reduce the waiting time during peak periods of operation.

8.2.5. Improved Cargo and Port Scheduling

Of the total delay time experienced by an ocean vessel within the Great Lakes-Seaway system, the major portion is expended waiting for port berthing space and for loading/unloading facilities to be made available. Substantial increases in vessel performance in terms of reduction of waiting time could be achieved if port turn around time could be reduced by improved intermodal scheduling and planning of available facilities and port resources.

8.2.6. Initiation of System Improvements

It takes seven to ten years for major changes to be introduced in system elements, for other system elements to compensate and for the system to stabilize. Included in this adjustment period is the time required for the trade to adapt to new opportunities and procedures. This relatively long time lapse makes it clear that one cannot wait until the system is saturated to find and implement an IMTIC solution. These constraints indicate that the requirement exists for the research and development of long lead time items (e.g., vessel location systems) to be initiated now.

8.3 IMPROVED SAFETY IN OPERATIONS

Over the past three years there has been an overall increase in ocean vessels entering the system for the first time. However, during this three year period, the quantity of ocean vessels which have consistently returned to the Seaway on an annual basis has remained essentially constant. There is a 20 percent change in the mix of ocean vessel returns each year.

These trends could indicate that newcomers to the system may be affected by the current level of Seaway safety performance. Preliminary data have indicated that a correlation exists between ocean vessels entering the system for the first time and accident frequency. Ocean ship's masters, unfamiliar with Seaway operations, using ocean oriented navigation and control equipment, do not have sufficiently rapid man-machine response times to cope with Seaway operations. The requirement exists for a traffic control and vessel location system which will enhance vessel performance by improving safety margins. Typical benefits of such a system could include the timely identification of potentially hazardous situations, positive vessel surveillance and surveillance during periods of adverse weather conditions, real time notification and identification of poor vessel performance - all these elements contributing to greater assurance of improved safety in operations.

9.0 SYSTEM IMPROVEMENTS AND BENEFITS

9.1 OVERALL

The overall benefits from a Traffic Control and Management Information System (IMTIC Steps 1 and 2) to the St. Lawrence-Great Lakes area, the shipping industry and the Seaway operating entities can be summarized as follows:

- Extended life of the St. Lawrence Seaway as a competitive mode of transportation and postponement of new costly construction. New facilities are estimated at over $1 billion.
- Better service to the shipping industry in safer operations and shorter transit time.
- Reduction in St. Lawrence River/Great Lakes pollution by tracking and identifying offenders and by reducing potential pollution - causing incidents.
- Accurate information for the shipping industry and operating personnel on the present and projected locations of vessels.
- More comprehensive and readily available planning data on vessels, cargoes, ports, canals, transits, and related subjects.
- Better information integration internally between operating entities and externally between agencies and companies.
- Consolidation and integration of resources competing for and rendering the same services, e.g., computers.
- More efficient utilization of the fleet.
- System improvement alternatives leading eventually to intermodal scheduling and planning. (IMTIC Step 2)

9.2 SUMMARY OF BENEFITS

The total benefits in terms of dollar savings, which could be attributable to a traffic control and management information system (IMTIC Steps 1 and 2) are shown in Table 9-1. These benefits are based on the expected level of utilization of the Seaway in the 1972-1980 period (IMTIC Step 1) and post-1980 period (IMTIC Step 2) and anticipate not only optimized vessel throughput but also improved port operations and in-port scheduling. Approximately 25 percent of the savings will be achieved in Step 1, most of them in the St. Lawrence-Lake Ontario-Lake Erie area; the remainder in the Upper Great Lakes in Step 2.

TABLE 9-1. POTENTIAL SAVINGS MILLIONS OF DOLLARS ANNUALLY

CATEGORY	IMTIC Step 1 (1972-1980)			IMTIC Step 2 (Post 1980)			
	Laker	Ocean	TOTAL	Laker	Ocean	TOTAL	TOTAL
Port Turn Around	0	$14.0	$14.0	0	$42.0	$42.0	$56.0
In Port Operations	0	$ 1.1	$ 1.1	0	$ 3.2	$ 3.2	$ 4.3
Vessel Transit Time	$0.7	$ 0.6	$ 1.3	*	*	*	$ 1.3
Pilotage*	-	$ 1.0	$ 1.0	**	**	**	$ 1.0
Safety*	-	$ 0.5	$ 0.5	-	-	-	$ 0.5
TOTALS	$0.7	$17.2	$17.9	0	$45.2	$45.2	$63.1
Reduction in Inventory (One Time Savings)	-	$ 0.7	$ 0.7		$ 2.2	$ 2.2	$ 2.9

* Further evaluation required

**Lost time data for Lake Erie and Upper Lakes (Districts 2 and 3) are unavailable

The savings in port operations and port scheduling are based on an integration of traffic control and management information throughout not only the Seaway but also the Upper Great Lakes area. These savings amount to over $60 million per year and affect the ship owner, the operator and eventually the consumer. Savings in port turn around time and in-port operations are based on the assumptions of improvements in facilities and resources as well as optimized scheduling of vessels, ports and cargoes. IMTIC can supply the information; how the information is used determines the extent of the benefits. Additionally, there are benefits such as improved pilot scheduling, enhanced safety in operations and upgrading in vessel performance which are quantified but require further evaluation.

9.3 QUANTIFIED BENEFITS

9.3.1. Port Turn Around Time

The reduction of ocean vessel port turn around time represents the most significant area for improvement in service of all categories of Seaway operations. The role of a traffic control and information system in this area would be principally in permitting the scheduling of the respective entities of port, dock and loading/unloading facilities and in expediting of the round trip transit time through the Seaway system. The typical ocean vessel in the Seaway system spends 8-10 days in transit and 14 to 22 days in 3-4 ports (Section 6). The in-port time is spent either alongside the dock waiting or actually engaged in loading and unloading cargo; or at anchor outside the port waiting for dock space to be available. This in-port time is a category wherein potential savings may be made.

Waiting time to enter port represents a non-productive use of resources and cargo. Through improved scheduling and, if possible, diversion of ships to ports with idle facilities, it is estimated that two to three days savings per vessel per port per trip may be achieved. These improvements may be translated into savings in vessel operating costs for the shipowner and reduced pipeline and inventory requirements for the shipper. The former savings are annual savings, while the latter are one-time reductions.

A sophisticated traffic control and management information system capable of planning and scheduling port traffic in the entire Fourth Coast area and effecting these estimated reductions is not expected until the post-1980 period (IMTIC Step 2). The dollar savings from this capability are listed below and are based on cargo, traffic and value forecasts for this period.

Vessel/Port Operations	$56,000,000	annually
In-Port Operations	$ 4,300,000	annually
Reduction in Inventory		
Bulk Cargo	$1,500,0000	one-time savings
General Cargo	$1,400,000	one-time savings

These savings may also be expressed in terms of added productivity to the vessel. Savings in port turn around time alone over a shipping season may be translated into an additional income producing trip for that vessel.

Improved in-port scheduling of unloading/loading facilities and resources offer another avenue for potential savings. The savings, accruing from improved efficiency in the utilization of dock-side storage space, cargo handling and moving facilities and cargo protection have been estimated at 1¢ per ton of cargo per hour saved. In the post-1980 period a management information system capable of scheduling these kinds of movements could be implemented. The savings from such a capability, projected into this period, would be $4,300,000 annually. This figure is based upon a reduction of six hours in unloading, loading and alongside time.

9.3.2 Traffic Improvements (IMTIC Step 1)

In Section 4 of this report increases in tonnage and number of transits have been projected. These increases have been reflected in longer average lock service times due to a shift in fleet mix toward longer, more cumbersome vessels of greater average capacity. The effect of the shift in fleet quantity and mix and the increase in lock service time was analyzed in Section 6. Traffic delays were projected through 1980. These projections indicated that average transit times through the Montreal-Lake Ontario section could increase as much as eight hours (Figure 6-3).

The data in Reference 10 indicate that optimized traffic patterning through the application of a planning algorithm could achieve a reduction of at least one minute per lock in lock service time. Such a reduction would be attributable to the control and scheduling of the vessel arrival rates, improved lock entries and exits and the patterning of vessels heading toward idle locks to have the lock cycle compatible with the vessel arrival. Using the methodology in Section 6 for the determination of transit times, the effect of a one minute reduction in lock service time was ascertained. These results are shown in Figure 9-1, and indicate that traffic planning can achieve at least a one-hour saving in transit time over that projected for the 1972-1980 period, and can maintain transit time at approximately the 1971 level. If lock service time increases sharply so as to require an average increase of six minutes per lock by 1980, then traffic planning can achieve a reduction of over 2.5 hours in the same period.

A reduction of one hour in transit time in 1980 is equivalent to $1,300,000 savings in vessel hours. Based upon a 55:45 Laker-Ocean mix, the savings are $700,000 and $600,000 respectively.

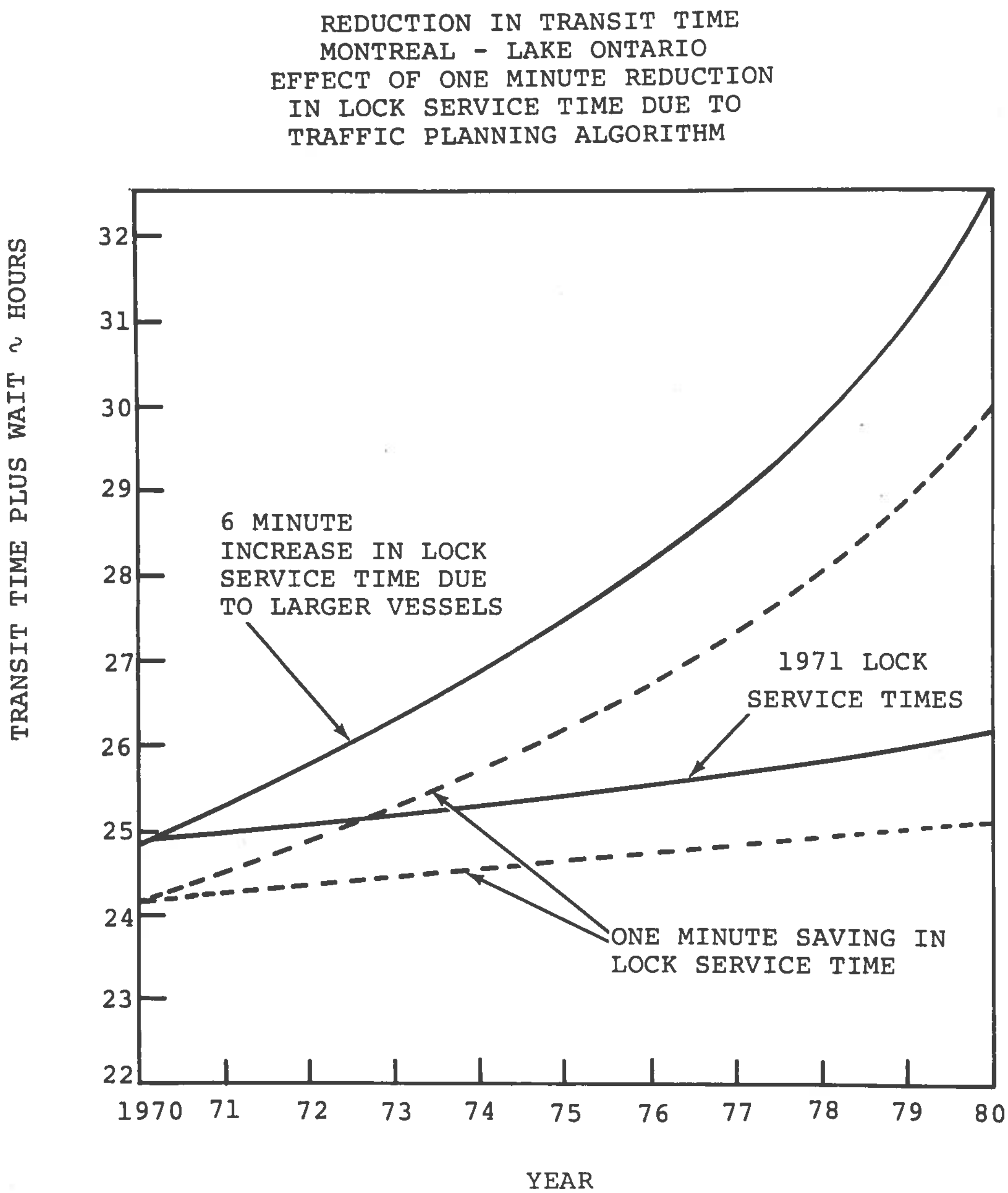


Figure 9-1 Effect of Service Improvements on Transit Time

The saving of one minute in lock service time per lock is a conservative estimate. Optimized traffic planning may achieve savings as much as three or more minutes. Additionally, facility improvements such as hydraulically assisted vessel exits from the locks and automated vessel mooring techniques may reduce lock service times even more, and greater savings in transit time may be achieved.

10.0 SYSTEM OVERVIEW

10.1 INTRODUCTION

The need for a traffic control, planning, management information and scheduling system has been discussed in the previous sections. The magnitude of the benefits, which could accrue from the implementation of such a system has been estimated. To achieve the level of system capability envisioned in these requirements and benefits analyses, an evolutionary system development is foreseen. This development encompasses a two-part effort. Step I has as its goal the achievement of a real time traffic control and management information capability. Step II builds upon the base that has been established in Step I and expands the system in coverage and capability to handle not only traffic control and cargo, but also fleet and port planning and management.

In addition to an evolutionary growth of system capability, there is a growth in geographic coverage as well. Step I covers only the St. Lawrence and Welland sections of the Seaway. Step II expands the Step I coverage to include the entire Fourth Coast area. The precision of the definition of the proposed systems is inversely related to the time span in which they are projected. The initial portions of Step I are fairly rigidly defined. The subsequent portions of Step I are less well defined. Step II is in the conceptual stage; the definition of Step II is properly the subject of a continuation of this study.

10.2 DATA REQUIREMENTS

The data needed for the Step I management information system are of two types. First is the routine information used for accounting and statistical purposes; cargo, length, draft, destination, agent and preclearance information. These data provide the basis for historical statistics, billing, patterns of Seaway utilization, and bases for vessel compliance with Seaway operating regulations. Second, and more important, is the information which defines not only the performance of the vessels transitting the Seaway system, but also the performance and constraints of the system itself. Typical of this information are the point-to-point transit times and the Estimated Time of Arrival (ETA) of the vessel at various control locations throughout the Seaway. The ETA data can be used to supply a list of approaching vessels to the control center. The vessel point-to-point transit times can be used to establish a measure of vessel performance as a function of vessel class, size, draft and the specific pilot or master on board. Further, these performance measures can be determined for various sections of the Seaway. System variables such as weather, incidents and delays, when they occur, can be used to modify the performance measures.

The data requirements for a traffic control system begin with measures of vessel and facility performance and include information on vessel location and disposition. Locational data can be based either on dead reckoned positions derived from a known position at a Call-In or Control Point or plotted on a near real time basis using vessel location and identification techniques. Vessel performance data are derived from historical information and are modified using current operational parameters. Optimized vessel patterning to achieve maximum control and throughput is derived using these data together with traffic planning algorithms.

The data requirements for Step II are undefined at present, however they should provide not only traffic control information but also detailed information with respect to port availability, port facility availability, vessels, cargoes and intermodal transportation availabilities.

10.3 STEP I - SEAWAY TRAFFIC CONTROL AND MANAGEMENT INFORMATION SYSTEM

The Step I system as proposed by the St. Lawrence Seaway Authority has as its objectives the optimization of Seaway throughput, the enhancement of safety in operations and the collection and consolidation of management and planning data. The ultimate output of Step I is a real time traffic control system for the Seaway. To achieve these objectives and goals, a four phase evolutionary system is postulated leading eventually to the total IMTIC System. The overall time-phasing of the IMTIC System is shown in TABLE 10-1 wherein system capability is defined by time, by equipment, and by function.

10.3.1 Phase I

Phase I has as its objective the integration of the Seaway's communication links and the development of a partially automated data collection and distribution capability. The achievement of these Phase I objectives creates a management information system and provides the base for the development of a traffic control system. Communication integration is attained through the use of message switching software which automatically links together the Welland Canal section, the Montreal-Lake Ontario section, and the Marine Information Center at Montreal and pilotage at Montreal and Port Weller. The subsequent phases will link the U.S. and Canadian entities including the St. Lawrence Seaway Development Corporation, the pilotage and harbor offices in the Great Lakes, St. Lawrence River and Gulf of St. Lawrence, Coast Guard Offices, Weather Agencies, and Radio Offices.

Phase I will also improve the current data storage and retrieval capacity by the addition of data base computers at St. Catharines in the Welland Canal section and at St. Lambert in the Montreal-Lake Ontario section. In the Montreal-Lake Ontario section, including both U.S. and Canadian sectors, vessel

TABLE 10-1 TIME PHASED IMTIC EVOLUTION

	TITLE	EQUIPMENT	CAPABILITY	FUNCTION OPTIONS Canadian	FUNCTION OPTIONS U.S.	INVESTMENT Canadian U.S.
Phase I 1972-73	Message Switching Information Distribution and Off-Line Lock Data Collection - St. Lawrence Section	2 Computers Software α/n CRT 2 Printers	-Data Storage -Limited Data Retrieval -Lock data (auto) -Manual Data Inputs	-Link Sections and M.I.C. -α/n Display at St. Lamb. St. Cath.	Upgrade ADC link to St. Lambert or nothing α/n Display or nothing	$120,000
Phase II 1972-74	Automated Lock Data Collection and Distribution St. Lawrence Section Partial Automated Traffic Control	-3rd Computer Graphic CRT Software -Upgrade Phase I Computers -200 line printer at Cornwall	-Automate, update -Wxx (man) -NAV (man) -Lock auto -DR Vessel location -Report Prep. (auto) -Prelim. Vessel Performance Analysis	-Central Control at Cornwall -Graphic Display at remaining locations -Link Pilots, Harbors, Radios	Link to Cornwall α/n or Graphic Display	$1,080,000
Phase III 1973-75	Semi-automated Traffic Control Automated Lock Data Collection and Distribution Welland Section	-Traffic Algorithm Software	-Improved D.R. Vessel Location -Near real time integrated traffic control data -Improved automated report preparation	-Optimized Seaway-wide traffic patterns	Graphic Display	$300,000
Phase IV 1972-76	Fully Automated Traffic Control (IMTIC)	AVLIS proposed equipment, e.g. -Loran -Pulsed, phase triangulation	-Real time vessel location and identification	Real Time Control (AVLIS)	Traffic	$3,000,000

entrance and exit times at the locks will be collected automatically but in this phase the information will be off line. The actual and estimated times of arrival at control points and calling-in points, plus the vessel entrance and exit times at the locks, will be manually inputted via CRT'S. This information will be manually updated with a daily report of completed and incompleted transits and preclearance information. The St. Lambert and St. Catharines control centers will be linked together using alpha-numeric CRT's to display the information together with teletype printers to provide hard copy.

The U.S. now supplies on-line lock entrance and exit data via test telemetry and experimental computer subsystems as well as actual and estimated vessel arrival times at call-in points via existing teletype network or telephone. The U.S. has the option in Phase I of upgrading its Automatic Data Collection (ADC) so as to link the St. Lawrence Seaway Development Corporation's control center in Massena, N.Y. with the St. Lambert-St. Catharines control centers. At this time, the U.S. may also include an alpha-numeric display as part of the ADC link.

Phase I is expected to be completed and in operation by April, 1973.

10.3.2. Phase II

In Phase II, the initial automated data collection and distribution capability which has been developed in Phase I is expanded and upgraded. This expanded capability also provides the basis for a limited automated traffic control system. In this phase, a central computer is established at Cornwall and the existing computers at St. Catharines and St. Lambert are expanded so as to be compatible. In the Montreal-Lake Ontario section, vessel entrance and exit times at the locks are automated and on-line. The system variables, weather, incidents and navigation information are inputted manually as well as call-in times and the actual and estimated times of arrival at the control points. Automated lock data collection and distribution and automated report preparation is available continuously on demand.

Data links with an automatic message switching capability will be expanded to include the following agencies:

- Pilotage offices at Les Escoumins, Quebec, Trois Rivieres and Port Huron
- Harbor offices at Montreal, Toronto and Hamilton
- Radios at Quebec, Trois Rivieres, Montreal, Kingston, Toronto
- Quebec Traffic Control
- U.S. and Canadian Coast Guard Offices

At this time complementary U.S. entities in the area served by the Seaway may link to the system. Such entities could include the U.S. Coast Guard, the Maritime Administration, the Corps of Engineers, Port Authorities in the St. Lawrence River, Lake Ontario and Lake Erie. (See Table 10-2).

Phase II also establishes the rudiments of an automated traffic control system by providing the capability for limited traffic analysis using automated lock data collection, manual call-in and control point data and dead reckoned vessel locations together with supporting software. The results of the traffic analysis, plus additional marine traffic information, are displayed using graphic CRT's at St. Lambert, St. Catharines and Cornwall.

By the start of Phase II, if the U.S. elects to participate in the system, the Seaway Development Corporation should be linked to the Canadian network via an ADC link to Cornwall. This will provide the U.S. sector with the same traffic information and vessel control data which is available to the Seaway Authority. Data display can be effected by either the rental of an alpha-numeric CRT or by the purchase of a graphic CRT terminal depending on the degree of sophistication required for vessel plotting.

Phase II is expected to be implemented by the commencement of the shipping season in 1974.

10.3.3. Phase III

Phase III is marked by system upgrading and expansion so as to provide a total Seaway capability for automated lock data collection and for semi-automated traffic control on a near real time basis. In this phase, the Welland Canal section automated lock data collection and distribution is placed on-line thereby integrating the data collection in this section with the Montreal-Lake Ontario section including the U.S. sector. The principal thrust of this phase is the development of a traffic planning algorithm so as to provide a capability for semi-automated traffic control. Using the real time lock data inputs and improved dead reckoning vessel location techniques, Seaway wide traffic patterns are analyzed and optimized on a near real time basis. No additional hardware is anticipated for the St. Lawrence Seaway Authority save for that necessary for on-line automated lock data collection for the Welland Canal section.

The U.S. option for Phase III is to upgrade the display function from alpha-numeric to graphic CRT, if this option has not been exercised during Phase II.

Phase III is planned to be implemented in the 1973-1975 period.

TABLE 10-2. PHASING GEOGRAPHICALLY - IMTIC

	St. Catharines	Cornwall	Massena	St. Lambert	MIC	Others
Present	2α/n CRT's PDP81 TTY	TTY	TTY	TTY PDP8S(ADC)	TTY	TTY
Phase I, IMTIC 1972-73	1 New Computer 5α/n CRT's Line Printer	TTY α/n CRT	TTY or α/n CRT	1 New Computer 5α/n CRT's PDP8S (ADC) off line Line Printer	TTY	TTY
Phase II, IMTIC 1972-74	Add to Computer 4 Graphic CRTs 2α/n CRTs Initial Planning -MIS software	TTY CRT-α/n or graphic Add Computer Initial P.M.S.	α/n or graphic CRT Initial P.M.S.	Add to Computer ADC on line 4 Graphic CRTs 2α/n CRTs Initial P.M.S.	TTY CRT?	TTY CRT
Phase III, IMTIC 1973-75	Planning Software - MIS Software	Planning Software MIS Software	Planning Software MIS Software	Planning Software MIS Software		

10.3.4 Phase IV

Phase IV represents the final step in the evolution of the fully automated traffic control and management information system (IMTIC). The principal objective of this phase is to develop a real time automated vessel location and identification system (AVLIS). This information system, together with the traffic planning algorithm developed in Phase III, will be used to optimize the traffic patterns in order to reduce delays and increase Seaway throughput. More importantly, AVLIS will provide the positive vessel location and identification necessary to provide the margin of safety required to conduct optimized Seaway operations under saturated and near saturated conditions. Additionally, at this time, the IMTIC System will have attained the capability of automatically collecting, storing and distributing vessel transit information throughout the Seaway system.

AVLIS is undefined at present but it may take many forms. It can include ship-based equipment, shore-based equipment or a combination of both. Some of the techniques which may be practicable include:

- Phase trilateration
- Pulse trilateration
- LORAN C
- OMEGA
- Proximity systems
- Inverse proximity systems
- Transponder systems

Phase IV, the AVLIS System, is planned to be implemented in the post-1975 period, however it is recommended that the advanced planning for this system be initiated now.

10.4 STEP II - SEAWAY AND FOURTH COAST TRAFFIC CONTROL AND MANAGEMENT INFORMATION SYSTEMS

Step II builds upon the base established by IMTIC and expands the system both in capability and in geographic coverage. The first objective of Step II is to provide traffic control throughout the Fourth Coast Area in order to maximize throughput through the Seaway and the Sault Ste. Marie. A necessary corollary to this objective is safety in operations, and it can only be achieved through the real time, positive vessel location and identification provided through AVLIS or a similar system.

The second and equally important objective of Step II is to provide optimum scheduling of vessels, ports, port facilities and cargoes. This objective represents an area wherein voluntary participation is necessary. The consolidation of such information, particularly with respect to cargo, consignor and vessel performance in a single data bank, is a valuable source of privileged information. Such data, if used improperly, could give a competitive edge to one shipper at the expense of others. Hence, the data for this bank must be supplied voluntarily, maintained by a government or impartial agency and properly safeguarded. Relevant data will be provided on demand to the shipper with respect to his cargo and vessel, alternate ports and available facilities. Widespread dissemination of such data will cause the user to lose confidence in the system's integrity. The overall distribution of such data will be limited to improving marine transportation and enhancing the interface between transportation modes.

The system specifics for Step II have not been determined and are beyond the scope of this present study. They are properly the subject for a supplementary effort.

The time frame for implementation of Step II is probably in the 10-year period after 1975.

11.0 - SYSTEM COSTS

11.1 INVESTMENT COST

The investment cost is the total expenditure required to install and place in an operating condition the IMTIC system. This cost category represents the costs essential to the implementation of the functional capability of the system. It is a joint U.S.-Canadian expenditure and subject to a cost sharing formula. The 27 percent/73 percent U.S.-Canadian revenue sharing formula for Seaway operations will be assumed to be valid in this case.

The investment cost is a one-time expenditure and does not include the R&D costs nor does it include the operating costs which are annual, recurring expenditures. Additionally, there are non-recurring costs which are specific to the U.S. and Canadian operation of IMTIC. These non-recurring costs do not enter in the total investment cost since the hardware represented by these non-recurring costs supplement the functional capability of the system. Examples of such hardware are additional CRT terminals and printers.

Overall, the U.S. will be expected to cost share part of the total investment cost of the St. Lawrence section and a portion of the Cornwall central control facility. On a 73-27 percent basis, this share will amount to $250,000.

Table 11-1 is a summary of the estimated IMTIC investment, recurring and non-recurring costs. These costs are estimated by phase and include U.S., Canadian and total commitment.

11.1.1 Phase I

The total investment for Phase I is $120,000 and includes data base computers at St. Catharines and St. Lambert plus associated software and peripherals. The estimated cost for the data base computers is $100,000; while the software and peripherals is $20,000. No U.S. or Canadian non-recurring costs are expected in Phase I.

11.1.2 Phase II

The Phase II investment cost is $1,080,000. Included in this investment cost is an additional computer at Cornwall, an upgrading in memory capability in the St. Catharines and St. Lambert computers, two graphic CRT terminals and associated software. The computer expansion and upgrading is estimated at $860,000; the graphic CRT terminals and software at $220,000. The $1.08 million investment cost for Phase II represents basic system capability. There are additional U.S. and Canadian non-recurring costs to reflect the hardware requirements of the respective entities. There is a $60,000 U.S. non-recurring cost to provide a graphic CRT terminal and printer at Massena. The Canadian non-recurring costs amount to $280,000 which provide for seven additional graphic CRT terminals throughout the Seaway system.

11.1.3 Phase III

By the end of Phase III a semi-automated traffic control capability will be achieved. The principal activity in this phase is the development and implementation of a traffic planning algorithm and associated software. The estimated investment cost for this effort is $300,000. No U.S. or Canadian non-recurring costs are expected.

11.1.4 Phase IV

Phase IV consists principally of the development of the Automated Vessel Location and Identification System. The cost of this system is dependent upon the configuration selected. Using a transponder based system this cost was estimated at $3 million. U.S. and Canadian non-recurring costs are dependent on the AVLIS method selected.

11.2 OPERATIONS AND MAINTENANCE COSTS

This cost category consists of the annual recurring costs associated with the rental of the operating equipment and the maintenance of the system. It is anticipated that the communications, and the alpha-numeric displays will be leased. These leased items are considered part of the O&M costs. Also included in this cost category is computer maintenance and additional personnel required to operate the system. (Table 11-1)

11.2.1 Phase I

The recurring costs for the Canadian portion of Phase I system amounts to $48,000 per year. This cost consists principally of the rental fees for the communication links ($18,000 per year) and the leasing of 10 alpha-numeric CRT terminals ($18,000 per year). Also included in this category is a $12,000 per year computer maintenance fee. If the U.S. elects to participate in the system during Phase I, then the U.S. would incur O&M costs of $5400 per year. This cost would consist of two alpha-numeric CRT terminals at $2400 per year, a printer at $2400 per year and additional communication links at $600 per year.

11.2.2 Phase II

The Phase II system is marked by an upgrading of the Phase I computer capability and a transition from leased alpha-numeric to purchased graphic CRT terminals. The Phase I recurring costs are superseded by the Phase II recurring costs. The Canadian recurring cost obligation consists of an annual charge of $116,800. Of this fee, communication links amount to $28,800 and system maintenance (including computer maintenance) to $88,000. The U.S. recurring cost obligation for Phase II is $22,200 per year. This figure con-

TABLE 11-1 ESTIMATED IMTIC HARDWARE, SOFTWARE (CAPITAL & RECURRING) COSTS/PHASE

	TOTAL INVESTMENT COST*		RECURRING COSTS (CANADIAN)		NON-RECURRING COSTS (CANADIAN)		RECURRING COSTS (U.S.)		NON-RECURRING COSTS (U.S.)	
	Equipment	Cost	Item	Cost	Item	Cost	Item	Cost	Item	Cost
Phase I 1972-1973	2 Computers	$100,000	-Communi- cations	$18,000/yr	none	none	2α/n CRT	$2400/yr	none	none
	Software & Peripherals	$ 20,000	-10α/n CRT	$18,000/yr			Printer	$2400/yr		
			-Computer Mainte- nance	$12,000/yr			Comm.	$ 600/yr		
	Total	$120,000		$48,000/yr				$5400/yr		
Phase II 1973-1974	Computer Expansion				7 Graphic CRTs	$280,000	Communi- cations	$1200/yr	1 graphic CRT & 200-line Printer	$60,000 (ést)
	existing computers	$860,000	-Communi- cations	$28,800/yr			Mainte- nance	$6000/yr		
	2 graphic CRTs	$220,000	-Mainte- nance	$88,000/yr			% of com- puter mainte- nance	$15000/yr		
	80K Software Total	$1,080,000		** $116,800/yr				$22200/yr		
Phase III 1973-1975	Traffic Algorithm Software	$300,000	Probable 2 pro- grammers	$30,000/yr	none	none	none probable	none	none probable	none
Phase IV 1972-1976	AVLIS	*** $3,000,000	Dependent on AVLIS method selected							
TOTAL		$4,500,000				$280,000				$60,000

* Subject to U.S. Canadian cost sharing agreements.
** Supersedes Phase I recurring costs.
*** Based on Transponder System.

sists of $1200 per year for communication links, $6000 per year for system maintenance and $15,000 per year for a U.S. share of the computer maintenance.

11.2.3 Phase III

The O&M costs committed for Phase II continue through Phase III. The Phase III objective centers around the development of a semi-automated traffic control capability and as such focusses on the construction and implementation of a traffic planning algorithm. The Canadian recurring costs consist of additional programming personnel necessary to support this capability. This cost is estimated at $30,000 per year. No additional U.S. recurring costs are anticipated in this phase.

11.2.4 Phase IV

Phase IV O&M costs are totally dependent upon the system configuration selected and on the configuration options within the system.

No estimate has been made of these costs.

11.3 Research and Development Costs

The foregoing costs consist principally of the costs necessary to implement and maintain the system as specified. There are additional historic costs associated with the research and development effort necessary to arrive at the current system specification. This effort has been conducted principally by the St. Lawrence Seaway Authority. These costs are summarized as follows:

Research and Development Effort by St. Lawrence Seaway Authority	$1.5 million
Equipment Development and Experimentation Including Automated Data Collection, Closed Circuit TV, Displays	$2.0 million
Kates, Peat, Marwick and Co. Contract for Upgrading Welland Section Operations	$2.5 million
	$6.0 million

In addition to the above "sunk" R&D costs there are current costs associated with the implementation of the IMTIC system. These costs cover the salaries and expenses of the personnel associated with the system implememtation and include both Canadian and U.S. personnel. These costs are estimated at $500,000 per year. In addition, Canada has appropriated $90,000 in FY 1972 toward the development of AVLIS.

12.0 SYSTEM SCHEDULE

12.1 INTRODUCTION

A phased development program is projected leading eventually to a Step I IMTIC capability. This capability is a real-time automated traffic control and traffic information system in operation by April 1976. In order to achieve this goal, each phase is conducted on a semi-concurrent, overlapping basis wherein one phase is initiated prior to the completion of the preceding phase. Using this approach, early decisions are necessary. However, sufficient information should be available upon which to make a reliable program decision. As preceding phases are completed, minor program revisions may be required based on updated data and experience.

Figure 12-1 is a tentative system implementation schedule showing the evolutionary build-up of system capability. This schedule indicates the interlocking arrangement of phases and the early initiation of long lead time efforts. Early initiation is particularly evident in Phase IV wherein the effort is started in early 1972, yet the phase is not scheduled for completion until April 1976.

12.2 PHASE I

The Phase I effort principally entails the development of a message switching capability plus initial data capture, storage, and retrieval.

This effort is underway now with a contract award expected by May 1972. Tested hardware is scheduled to be delivered by August with the software ready two months later. System installation would be completed and tested at St. Lambert by mid December; the St. Catharines' installation by January 1973 and the system would be on-line by April 1973. Not shown in Figure 12-1 are the U.S. options or commitments. It is anticipated that the installation of U.S. data links and the procurement and testing of hardware could be compatible with the overall schedule as shown.

12.3 PHASE II

Phase II is initiated in mid-1972 shortly after the Phase I hardware has been delivered. The Phase II effort includes the installation of an additional computer in Cornwall, Ontario and the upgrading of the existing computers. The principal thrust of the Phase II effort is towards the implementation of a vessel and traffic information system and the initial development of a traffic planning system. The Phase II implementation schedule follows a similar pattern to that of Phase I.

System specifications would be developed in 1972 and modified using preliminary Phase I experience. A contract award date of March 1973 is planned. Computer installation and expansion would

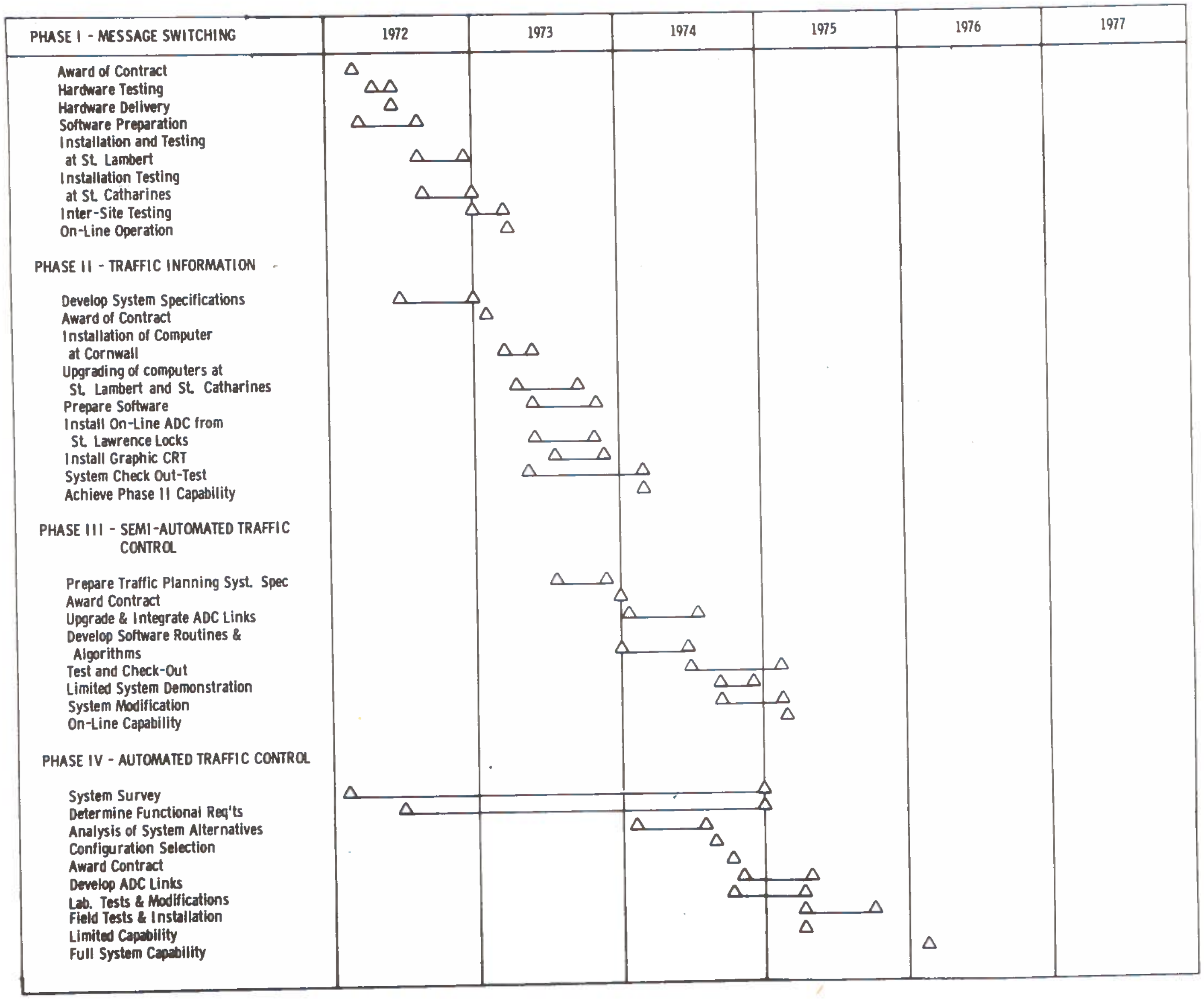


Figure 12-1 IMTIC Schedule

be complete by September 1973. Supporting software would be prepared in the five month period, June-November 1973. The installation of ADC links from the St. Lawrence River locks and graphic CRT displays are planned for Nov. 1973. The period from June 1973 to April 1974 would be spent in subsystem, component and interactive system check-out and test with the goal of achieving on-line Phase II capability by April 1974.

The U.S. involvement in Phase II could be conducted in parallel with the Canadian effort, specifically the ADC links and the installation and linking of the graphic CRT displays.

12.4 Phase III

The principal objective of Phase III is the achievement of a semi-automated traffic control capability through the development of a traffic planning program and associated algorithms. Planning for the Phase III effort is initiated in mid 1973 and consists of the development of the requirements and specifications for the traffic optimization program. Data and experience from Phases I and II are used as inputs to the specifications. Contract award date is expected in February 1974 with an output due August 1974. In parallel with the development of the traffic planning and control program, the data links in the Welland section will be upgraded to provide on-line lock data information; these data links will be integrated with the automatic data collection system in the Montreal-Lake Ontario section. This task is expected to be completed by mid August 1974. Between August and April 1975 system tests and checkouts will be conducted. By October 1974 a limited demonstration of the semi-automated traffic control capabilities will be held. Based on the results of the system demonstration and the continuing test and evaluation program, system modifications will be made. By April 1975 an on-line capability is expected.

12.5 PHASE IV

With the completion of Phase IV, full IMTIC capability is attained. Phase IV provides the real-time, vessel location and identification system necessary for automated traffic control. A four year development program is projected leading to Phase IV implementation (and IMTIC implementation as well) by April 1976. In order to meet the goals of this schedule, the initial planning and analysis should be initiated early in 1972. This effort involves a continuing survey of current and projected vehicle location/identification systems. The purpose of this effort is to develop a data base of system capabilities against which IMTIC system functional requirements can be compared. In parallel with the system survey there is a comparison task to determine the functional requirements for AVLIS. The functional requirements are based on system design capabilities as modified by Phase I, II and III experience. The survey and requirements efforts are expected to continue into early 1974 at which time candidate systems will be compared and a configuration selected. Contract award to a system supplier is expected late in 1974. A testing program will be initiated shortly thereafter to determine performance and reliability parameters. In the spring of 1975 a field test and installation effort will be undertaken. Concurrently automatic data collection links will be established. By September 1975 a limited system capability should be available sufficient to demonstrate system performance. In spring 1976 fully automated traffic control is expected.

The foregoing phased development program is indicative of the type of system evolution which may be expected with IMTIC. The schedule shown is not rigidly defined at this time but is only for planning purposes.

13.0 RECOMMENDATIONS

The following recommendations are derived from this study:

- U.S. proceed in cooperation with the Canadian Government with the implementation of IMTIC Step I. This system would be developed as a joint venture between the St. Lawrence Seaway Development Corporation and the St. Lawrence Seaway Authority.

- Funding for system implementation be accomplished in the following manner:

  - Department of Transportation fund the investment cost ($300,000) for Phases I through III

  - St. Lawrence Seaway Development Corporation fund the recurring costs for all phases. Recurring costs are currently estimated at $50,000 per year

  - Research, development, and implementation costs for Phase IV be funded jointly by the Department of Transportation and other concerned entities.

- St. Lawrence Seaway Development Corporation upgrade its existing data link to St. Lambert so as to be compatible with the specifications for IMTIC Step I.

- St. Lawrence Seaway Development Corporation install a graphic CRT at Massena, N.Y. compatible with the time phased capabilities of IMTIC Step I.

- Department of Transportation in cooperation with other concerned entities initiate a program to develop, test, and demonstrate the technical and economic feasibility of vessel location and identification systems.

- Using the analysis and results of this study as background, Department of Transportation initiate an immediate systems and requirements analysis of traffic control and vessel/cargo information systems for the entire St. Lawrence River-Great Lakes area.

- DOT should invite other U.S. and Canadian maritime entities to establish an interagency task force which would serve as a coordinating and integrating body for all vessel/cargo control and information system programs in the Great Lakes St. Lawrence River area. Task Force to be constituted with membership from the following U.S. agencies and their Canadian counterparts.

- U.S. Army, Corps of Engineers
- U.S. Coast Guard
- St. Lawrence Seaway Development Corporation
- Maritime Administration
- National Oceanographic and Atmospheric Administration
- Federal Communications Commission

- Task Force to serve as an investigating and coordination body. Work assignments to be given to task force study groups to perform studies and investigations of identified problems. A major assignment: Preparation of a unified technical development plan for a U.S./Canadian traffic control and vessel/cargo information system for the Fourth Coast.

- Under Department of Transportation and/or Task Force sponsorship, research be initiated to determine the feasibility of expanding the capability of IMTIC I so as to be able to collect, retain and disseminate detailed cargo, shipping and port information.

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APPENDIX A

OCEAN VESSEL TRANSIT

HISTORIES - 1970

TABLE A-1 1970 VESSEL TRANSITS - OCEAN

VESSEL NAME	PRECLEARANCE NUMBER	ENTER MONTH	SYSTEM DAY	LEAVE MONTH	SYSTEM DAY	ELAPSED TIME-DAYS	SYSTEM DESTINATION: LAKE ONTARIO	LAKE ERIE	UPPER LAKES
Marus									
Astoria	6662	8	20	9	9	20			X
Aizu	6526	9	18	10	9	21			X
Akagi		6	19	7	17	28			X
Akita	6549	5	15	6	13	29			X
Akashisan	6436	5	7	6	2	26			X
Asama	6511	11	6	11	11	5	X		
Atami	6867		-	8	9	-			
Bolivia	6149	-		6	27	-			
Buko	7517	-		7	24	-			
Gloria	6661	-		5	21	-			
Goshu	7485	5	14	6	7	24			X
			-	11	3	-			
Hamburg	6437	-		5	5	-			
		8	30	9	21	22			X
Honolulu	7063	7	28	8	22	25			X
	-			5	10	-			
Kimikawa	5947	9	11	9	29	18			X
Mayasan	5511	6	30	7	16	17		X	
		11	5	11	21	16		X	
Manjusan	6868		-	6	19	-			
		10	5	10	25	20		X	
Masashima	5475	11	9	11	21	12	X		
Mikagesan	5539	11	2	11	27	25			X
Mikishima	5841	11	7	11	27	20			X
Mogomisan	5719	9	28	10	20	22			X
Montevido	6438	-		5	25	-			
		9	8	9	29	21		X	
Montreal	7435		-	5	9	-			
		8	7	8	25	18		X	
Oppama	7486	-		5	7	-			
Peru	7604	11	9		-	-			
Seattle	6943	-		11	19	-			
St. Lawrence	7593	10	4	10	24	20			X
Wakatake	7473	5	1	5	12	11	X		
Yanagi	7555	8	25	9	14	19		X	
Liners									
Senatore	6987	6	11	6	27	16		X	
		8	9	8	27	18		X	
		9	28	10	6	9	X		
		11	9	11	22	13		X	

TABLE A-1 1970 VESSEL TRANSITS - OCEAN (CONTINUED)

VESSEL NAME	PRECLEARANCE NUMBER	ENTER SYSTEM MONTH	ENTER SYSTEM DAY	LEAVE SYSTEM MONTH	LEAVE SYSTEM DAY	ELAPSED TIME-DAYS	SYSTEM DESTINATION LAKE ONTARIO	SYSTEM DESTINATION LAKE ERIE	SYSTEM DESTINATION UPPER LAKES
Dyvi-Atlantic	6790	5	7	-					
		6	5	6	10	5	X		
		7	20		-	-			
		11	23		-	-			
Dyvi-Pacific	7512	6	8	6	11	3	X		
		7	2	7	11	9		X	
		8	1	8	9	8		X	
		10	13	10	18	5	X		
		11	6	11	13	7		X	
Manchester Port'	6821	5	24	6	16	23			X
			-	11	9	-			
Manchester Com-merce	6130		-	5	2	-			
		6	11	7	7	26			X
		8	27		-	-			
		10	20	11	16	27			X
Manchester City	6358	5	4	5	26	21			X
		6	29		-	-			
		9	22	10	7	16		X	
Manchester Pro-gress	5588		-	5	16	-			
		6	23	7	10	17			X
		9	4	9	24	20			X
		10	31	11	24	25			X
Manchester Re-nown	6222	-		5	5	-			
		7	18	8	10	21			X
Trans America	7562	9	24	10	18	25			X
		9	1	9	19	18			X
		10	27	11	19	23			X
Trans Atlantic	5590	5	19	6	16	27			X
		7	15	8	5	21			X
		9	8		-	-			
		11	6		-	-			
Trans Germania	6180	5	2	5	17	15			X
		6	27		-	-			
		8	22	9	6	14			X
		10	19	11	4	16			X
Trans Michigan	6775	-		5	12	-			
		6	16	7	4	18			X
		8	12	9	1	20			X
		10	8	10	27	19			X
Trans Ontario	5128	-		5	2	-			
		6	9	6	24	15			X
		7	29	8	15	17			X

TABLE A-1 1970 VESSEL TRANSITS - OCEAN (CONTINUED)

VESSEL NUMBER	PRECLEARANCE NUMBER	ENTER SYSTEM MONTH	ENTER SYSTEM DAY	LEAVE SYSTEM MONTH	LEAVE SYSTEM DAY	ELAPSED TIME-DAYS	SYSTEM DESTINATION LAKE ONTARIO	SYSTEM DESTINATION LAKE ERIE	SYSTEM DESTINATION UPPER LAKES
Trans Ontario (cont.)	5128	9	23	-		-			
		11	20	-		-			
Trans Pacific	5572	6	8	6	24	16			X
		8	8	8	23	15			X
		-		10	29	-			
Ulysses Castle	7386	6	6	6	28	22			X
		-		9	14	-			
		10	28	-		-			
Ulysses Island	7472	-		5	18	-			
		9	18	10	8	20			X
Ulysses Ogygia	7539	7	13	7	30	17		X	
		-		9	28	-			
		11	5	-		-			
Ulysses Reefer	7359	5	19	6	9	21			X
		7	21	8	17	27			X
		10	16	11	8	23			X
Inga Bastian	6898	5	19	5	26	7	X		
		6	29	7	8	9		X	
		-		8	27	-			
		9	26	10	1	5	X		
		11	2	11	7	5	X		
Hadar	6241	-		5	5	-			
		7	4	7	22	18		X	
		9	19	10	20	31			X
Topdalsfjord	5165	5	28	6	16	19			X
		18	19	9	3	15			X
		10	23	11	17	25			X

TABLE A-1 1970 VESSEL TRANSITS - OCEAN (CONTINUED)

Vessel Name	PRECLEARANCE NUMBER	ENTER SYSTEM		LEAVE SYSTEM		ELAPSED TIME-DAYS	SYSTEM DESTINATION		
		MONTH	DAY	MONTH	DAY		LAKE ONTARIO	LAKE ERIE	UPPER LAKES
Alka	6918		-	5	10	-			
		7	24	8	9	16			X
				11	9				
Andwi	7367	5	5	5	26	21			X
		7	1	7	26	25			X
		9	5	9	20	15			X
				11	6	-			
Rolwi	7078		-	5	14	-			
		6	25	7	11	16			X
		9	26	10	17	22			X
		11	21		-	-			
Poseiden	6017	5	30	6	11	12		X	
		7	25	8	3	9		X	
		9	22	10	7	15		X	
		11	21	11	30	9			
Anna Rehder	6932		-	5	19	-			
		6	28	7	7	10		X	
		8	24	9	5	11		X	
				10	22	-			
Matthias	7299	5	10		-	-			
Rehder		6	9	6	21	11		X	
		7	25	8	18	24		X	
		9	24	10	12	18		X	
Donetski Kom-	7489	5	7	5	14	7	X		
somolets		6	5		-	-			
				9	1	-			
Donetski	7468	7	24	7	30	6	X		
Metallurg		10	28	11	4	6	X		
Dimitrios DM	5716	5	21	5	25	4	X		
		6	28	7	02	4	X		
		7	30	8	4	5	X		
		8	31	9	4	5	X		
Falcon	5272	7	6	7	11	5	X		
		5	15	5	19	4	X		
		9	11	9	16	5	X		
Anette	6053		-	5	13	-			
		6	18	7	9	21		X	
		8	8	8	24	16		X	
		9	24	10	10	16		X	