

UNITED STATES DEPARTMENT OF COMMERCE

JESSE H. JONES, *Secretary*

The St. Lawrence Survey

PART II

Shipping Services on the St. Lawrence River



N. R. DANIELIAN, *Director*

ST. LAWRENCE SURVEY

Reports of the St. Lawrence Survey

- PART I. History of the St. Lawrence Project.
- PART II. Shipping Services on the St. Lawrence River.
- PART III. Potential Traffic on the St. Lawrence Seaway.
- PART IV. The Effect of the St. Lawrence Seaway upon Existing Harbors.
- PART V. The St. Lawrence Seaway and Future Transportation Requirements.
- PART VI. The Economic Effects of the St. Lawrence Power Project.
- PART VII. Summary Report of the St. Lawrence Survey.

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UNITED STATES
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DECEMBER 20, 1940.

THE PRESIDENT,
THE WHITE HOUSE,
Washington, D. C.

DEAR MR. PRESIDENT: I have the honor to transmit herewith Part II of the reports of the St. Lawrence Survey being conducted by the Office of the Secretary of Commerce. This part discusses the physical aspects of the proposed St. Lawrence Seaway, the conditions of navigation, and the possibilities of ocean shipping over this new route.

A summary of facts and conclusions is given in the letter of submittal of Dr. N. R. Danielian, Director of the St. Lawrence Survey.

Very sincerely yours,

WAYNE C. TAYLOR,
Acting Secretary of Commerce.

LETTER OF SUBMITTAL

DECEMBER 18, 1940.

The Hon. SECRETARY OF COMMERCE,
Washington, D. C.

DEAR MR. SECRETARY: I have the honor to submit to you the second of a series of reports on the feasibility of the St. Lawrence seaway and power project. This report deals with the navigational aspects of the present waterway and the proposed improvement.

In its preparation the Survey has had the full cooperation of Admiral E. S. Land, Chairman of the United States Maritime Commission; Brigadier General Thomas M. Robins, Assistant Chief of Engineers, United States Army, and staff members of the Board of Engineers for Rivers and Harbors; Mr. E. B. Jost, General Superintendent of Canals, Canada; Mr. C. W. West, Superintending Engineer, Welland Canal, Ontario; Mr. H. McClymont, operating manager, Canada Steamship Lines, Ltd., and the Dominion Bureau of Statistics, Canada. Although the Director of the Survey assumes full responsibility for the report, the assistance of these gentlemen and their organizations has been of immeasurable value in making available new and important facts bearing on the feasibility of the St. Lawrence Seaway as a channel of navigation. To them the Survey owes a debt of gratitude.

In this report there is a description of the physical aspects of the existing and proposed route from Duluth on Lake Superior to Montreal, the type of traffic utilizing the present St. Lawrence canals, and the conditions of navigation prevailing in the river. The major objections against the project from the standpoint of navigation are here examined minutely in the light of available facts.

Briefly, the objections to the seaway have questioned, among other things, the adaptability of the St. Lawrence route to ocean shipping on the grounds that the navigation season is limited, that unfavorable weather conditions and restricted, tortuous channels make navigation and ship operation hazardous, and that a 27-foot canal project would exclude a large part of world shipping. These are serious charges, and have received careful consideration in this report.

The existing Great Lakes-St. Lawrence system appears much like an hourglass—deep and wide at both ends, and narrow and shallow in its center portion. The Great Lakes are large bodies of water con-

nected by channels 21 feet deep up-bound and 25 feet deep down-bound. On the opposite end, at Montreal and eastward, there is a first-class ocean ship channel with a minimum depth of 32 feet which is being further deepened to 35 feet. Between the lower end of Lake Ontario and Montreal, through navigation is limited to 14-foot draft. The swift flowing rapids at Long Sault, Soulanges, and Lachine are circumvented by a total of 47 miles of canals and 22 locks.

Under the engineering plans prepared by Canada and the United States it is proposed to improve the 183 miles of the river between the foot of Lake Ontario and Montreal by means of dams, eight locks, canal links, and deepened river channels to accommodate modern ocean-going vessels; also, to deepen the connecting channels of the Great Lakes so that these same ocean vessels can reach the major cities spotted along the shore line of the Lakes, gateways for a great and rich industrial and agricultural hinterland. All channels will have a minimum depth of 27 feet and a minimum width of 450 feet. All locks will have a length of 859 feet, width of 80 feet, and depth over the sills of 30 feet.

Despite its limitation to a depth of 14 feet, the present St. Lawrence canal system is one of the busiest waterways of the North American Continent. A large amount of commerce passes over the upper river between the Great Lakes and Montreal. This traffic has grown steadily from 2,000,000 tons in 1910 to more than 8,000,000 tons in 1938; and in late years local or way traffic has amounted to an additional 1,000,000 tons. Grain, petroleum products, pulp and pulpwood, coal, ore, and iron and steel products are the principal items of freight tonnage carried on the present canals. It is significant that included in this traffic is a sizable transoceanic business. During the 3-year period 1937-39, for example, there moved directly, between Lake ports and European ports, approximately 600,000 tons of freight, requiring over 400 trips by small oceangoing freighters. This direct service was provided by Norwegian and Dutch lines which had constructed specially designed ships for this purpose.

One of the criticisms of the project has been that the St. Lawrence route will be closed a good part of the year on account of ice conditions; this reduces its commercial usefulness and creates the problem of finding employment for ships in other routes during the closed season. This claim is made on the grounds that navigation service on the St. Lawrence, using Montreal as a starting point, will be restricted to 6½ months a year, the season opening and closing at Montreal about May 1 and the middle of November, respectively. On this premise it has been claimed that use of the route would not be profitable to the shipping industry. An analysis of the facts shows that this conclusion is too drastic. The length of open naviga-

tion season at Montreal averaged 231 days during the 20 years 1920-39. On the St. Lawrence canals it was 237 days; on the Welland Ship Canal, 245 days; and at the Sault Ste. Marie, 253 days. Taking the latest date of opening and earliest date of closing at Montreal during those 20 years, it is found that the season extends from May 3 to December 1, which permits the last out-bound ship to leave Duluth as late as November 25.

Furthermore, it is erroneous to calculate the navigation season at Montreal. Where the problem concerns the ship lines, the actual working time of ships is the consideration at issue. From this point of view, the operating season of ships destined to Great Lakes ports would start at least 2 weeks or more before the opening of navigation at Montreal; ships could start from European or South American ports sometime in April in order to reach Montreal by May 3. Similarly, on the last trip out, time must be allowed to reach the ship's ultimate destination, which would keep the boats in profitable operation late in December. Actually, the vessel would be in St. Lawrence service for 8 months or more, depending on the distance of the ports of origin and destination from Montreal. About a month must be allowed for drydocking, inspections, repairs, etc., which means that the vessel would be compelled to seek other trade routes for only 3 months or less in a year. In trade routes to the Mediterranean, to the Pacific coast, or to the Orient, the season of profitable Great Lakes traffic would be still longer and the period during which other occupation must be found would be substantially shorter.

The charge has also been made that the restricted river channels, the canal sections, and the locks between Montreal and the head of the Lakes would slow down oceangoing vessels to three-quarters of normal sea speed, equivalent to a loss of 3 days per round trip. This is not in line with the facts. The report discloses that under the proposed plans of improvement there will be 1,273 miles of open water navigation between Montreal and Duluth; 67 miles of canals, 8 miles of restricted channels, and 18 locks. On the basis of officially recorded transit time at the Soo and through the Welland Ship Canal, and in the light of the speed limits imposed by regulations of appropriate Canadian and United States authorities in St. Marys, St. Clair, Detroit, and the upper St. Lawrence Rivers, it is found that the time for passage between Montreal and Duluth will be approximately $5\frac{1}{2}$ days. Actually, this means a delay of 18.5 hours in each direction, or a retardation over normal speeds for a boat making 12 miles per hour of only $1\frac{1}{2}$ days per round trip. Stated in another way, the average speed for a vessel normally steaming at 12 miles per hour would be reduced to an over-all speed of about 10.4 miles per hour.

The assertion has been made that the upper St. Lawrence is a

nected by channels 21 feet deep up-bound and 25 feet deep down-bound. On the opposite end, at Montreal and eastward, there is a first-class ocean ship channel with a minimum depth of 32 feet which is being further deepened to 35 feet. Between the lower end of Lake Ontario and Montreal, through navigation is limited to 14-foot draft. The swift flowing rapids at Long Sault, Soulanges, and Lachine are circumvented by a total of 47 miles of canals and 22 locks.

Under the engineering plans prepared by Canada and the United States it is proposed to improve the 183 miles of the river between the foot of Lake Ontario and Montreal by means of dams, eight locks, canal links, and deepened river channels to accommodate modern ocean-going vessels; also, to deepen the connecting channels of the Great Lakes so that these same ocean vessels can reach the major cities spotted along the shore line of the Lakes, gateways for a great and rich industrial and agricultural hinterland. All channels will have a minimum depth of 27 feet and a minimum width of 450 feet. All locks will have a length of 859 feet, width of 80 feet, and depth over the sills of 30 feet.

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One of the criticisms of the project has been that the St. Lawrence route will be closed a good part of the year on account of ice conditions; this reduces its commercial usefulness and creates the problem of finding employment for ships in other routes during the closed season. This claim is made on the grounds that navigation service on the St. Lawrence, using Montreal as a starting point, will be restricted to 6½ months a year, the season opening and closing at Montreal about May 1 and the middle of November, respectively. On this premise it has been claimed that use of the route would not be profitable to the shipping industry. An analysis of the facts shows that this conclusion is too drastic. The length of open naviga-

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The assertion has been made that the upper St. Lawrence is a

tortuous route through areas of dense fog. The report analyzes this contention in the light of official statistics showing the hours of fog recorded at several points along the route, the number of vessel passages, and the number of accidents. These data show the assertions to be considerably exaggerated. It is found that fog conditions during the open season are more favorable than those prevailing at New York harbor. Moreover, during the 5-year period 1935-39, when there were more than 50,000 vessel passages engaged in commerce on the upper St. Lawrence River between Lake Ontario and Montreal, there were only 116 accidents. Of these, 82 resulted in damages and 34 involved no damages at all, with total monetary damage reported amounting to approximately \$419,000. In 76 instances the weather was clear and in 40 instances, foggy or stormy conditions prevailed. This record is quite favorable compared with the record of accidents on the Panama Canal during the same period.

One of the most insistent objections to the St. Lawrence Seaway has been that a 27-foot project would not permit any appreciable proportion of ships engaged in American traffic to utilize it. The report presents a comprehensive analysis of the portion of present-day oceangoing vessel tonnage that could use the St. Lawrence project at its initially proposed depth of 27 feet. The analysis is based on data compiled by the United States Maritime Commission. The facts show that the world's merchant fleet comprised, as of December 31, 1939, 9,200 vessels of 52,000,000 gross tons. Of these, freight ships numbered 6,403 with 30,000,000 gross tons, of which 71 percent of the vessels and 59 percent of the freighter gross tonnage would find safe and convenient navigation in the 27-foot project. The United States share of the world fleet amounted then to 1,300 vessels and 7,900,000 gross tons, of which 800 vessels and 4,000,000 gross tons are of the freighter class. The project would accommodate 65 percent of these freighters and 56 percent of their gross tonnage.†

These segregations of ships suitable for navigation on the 27-foot St. Lawrence project are based on vessels having maximum or registered drafts of 25 feet, and assume that the ships would be loaded to full maximum draft. To the extent that this is not always the case, many more ships with registered drafts even greater than 25 feet could navigate the channels. Critics of the project have neglected to take this factor into consideration. Ships draw less than registered draft if they are not fully loaded. Ships do make profitable runs at 5, 10, or 15 percent less load than their maximum capacity. But this is not the only condition when actual drafts of vessels are less than registered drafts. A ship may have its holds fully loaded, with every inch of space occupied, but if the density of the cargo is light, as in the case of cotton or jute and burlap, then it would not draw

† The effect of destruction of ships in the course of the present war on these figures cannot be foretold.

its maximum draft. Again, consumption of fuel, water, and supplies would make a difference of 1 to 2½ feet in draft at the time of arrival at Montreal after a long voyage. A test analysis of the actual draft of vessels passing through the Panama Canal in the month of July 1939 shows that a large majority of those traveling in cargo had less than registered draft. In almost a third of the cases, the actual draft was 2 feet less than the registered draft. These considerations lead to the conclusion that the usability of a 27-foot project on the St. Lawrence would not be restricted to ships having registered drafts of 25 feet or less, sufficient though these ships are in number and carrying capacity to take care of Great Lakes traffic.

An additional consideration reduces the significance of traditional analyses based on registered drafts. Shipping lines design and construct their new ships having in mind the character and limitations of the channels which they expect to utilize. This is attested to by the United States Maritime Commission. It is also sustained by the history of shipping on the Great Lakes and the present St. Lawrence canals. Given reasonable dimensions, it can be expected that the St. Lawrence route will, in time, admit ships built to a considerable extent for that particular service.

On the basis of all the facts contained in this report, the Survey draws the following conclusions from its study of the conditions and limitations of navigation on the St. Lawrence Seaway:

1. The development of the upper St. Lawrence to a depth of initially 27 feet would provide a satisfactory waterway 2,350 miles into the heart of the North American Continent. Over this distance there would be only 67 miles of canals, 8 miles of restricted channels, and 18 locks.

2. Though by no means as unencumbered as shipping on the high seas, yet the conditions of navigation on the St. Lawrence are not so difficult or hazardous as to make extensive utilization impossible.

3. The season of navigation, though restricted, is not so short, considering the length of revenue-producing operations permitted, as to make the St. Lawrence route unattractive to shipping lines.

4. There are, in normal times, enough ships of required draft to navigate a 27-foot channel as proposed. In the light of the factors here cited, it can be confidently expected that there will be enough ships able to navigate from the ocean to the Lakes to take care of available traffic.

There are, then, no physical or climatic reasons why the St. Lawrence route should be unattractive to shipping lines a good part of each year. The only considerations which will govern the actions of ship owners are economic—principally, the availability of cargo at profitable rates. This subject is extensively analyzed in Part III of these reports.

X

LETTER OF SUBMITTAL

Although the analysis of ship drafts has been confined principally to merchant vessels, the Survey extended its examination to include a comparison of the dimensions of United States naval vessels with the limitations of the proposed St. Lawrence Seaway. This study shows that all classes of cruisers, destroyers, and submarines can easily navigate the St. Lawrence Seaway in ample safety. Only battleships and aircraft carriers could not be accommodated in the locks because of limitations of width and depth.

Very truly yours,

N. R. DANIELIAN, *Director,*
St. Lawrence Survey.

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SHIPPING SERVICES ON THE ST. LAWRENCE RIVER

INTRODUCTION

It is the purpose of this report to analyze and discuss the physical factors which affect navigation on the St. Lawrence River. These factors are principally the depth of channel required for ocean shipping, the navigational conditions prevalent on the river, and the time of passage. Severe criticism of the St. Lawrence Seaway project has been expressed on the grounds that the short season of navigation would militate against ocean shipping; ice conditions at the beginning and end of each season, fog and storm, and the tortuous and restricted channels would make navigation hazardous; that the long journey up the river and through the Lakes would be slow; and that the proposed initial depth of 27 feet would not permit any considerable portion of American and foreign shipping to utilize the canals. These assertions, on the other hand, have been denied by proponents of the Seaway, the engineers of both Canada and the United States, and representatives of the Maritime Commission. In this report the available facts bearing on these controversial questions will be explained and discussed.

Section I

THE SEAWAY PROJECT

It is generally known that the Great Lakes provide a vital system of transportation to the landlocked civilization of the Middle West. A glance at the facts will reaffirm the importance of traffic in this region. In 1938, water-borne commerce traversing the Lakes amounted to 108 million tons, almost one-fourth of all the water-borne commerce of the United States, including the Atlantic, Gulf, and Pacific coasts. Iron ore, soft and hard coal, various kinds of grains, and stone comprised nearly three-fourths of this water-borne commerce.¹ On the Great Lakes there was a fleet of 850 vessels of all descriptions, with total gross tonnage of 3,300,000, of which by far the largest proportion, 559 vessels with 2,572,000 gross tons, belonged to United States registry.² It is not a matter of accident, of course, that many of the largest cities of the United States—Buffalo, Cleveland, Detroit, Chicago, and Milwaukee—are located directly on this natural waterway. Other municipalities not so large but equally prominent as centers of industrial activity are within short distance of the Great Lakes—Syracuse, Rochester, and Niagara Falls, N. Y.; Pittsburgh,

¹ Lake Carriers' Association, *Annual Report*, 1938, p. 41.

² *Ibid.*, p. 46.

Pa.; Youngstown, Canton, and Akron, Ohio; Indianapolis, Ind.; Joliet, Ill.; Minneapolis and St. Paul, Minn.

Unfortunately, this great body of water, which acts as a channel of transportation for the products of rich mines, agriculture, and industry, is sealed to the outside world by obstructions in the path of the St. Lawrence River which carries the flow of the Lakes to the Atlantic Ocean. These obstructions now hinder but a short interval in the 2,350 miles of waterway from Duluth to the entrance of the St. Lawrence River at Belle Isle, near Newfoundland. Unobstructed navigation is now available over the 1,164 miles of this total distance which lie in the Great Lakes. Canals and locks at St. Mary's Falls between Lake Superior and Lake Huron, the removal of obstructions from St. Clair River, Lake St. Clair, and Detroit River, and the construction of the Welland Ship Canal to scale the Niagara escarpment between Lake Erie and Lake Ontario, have created an uninterrupted course from Duluth, Minn., to Ogdensburg, N. Y., and Prescott, Ontario. The upper part of the St. Lawrence River from Lake Ontario to Prescott, a distance of 64 miles through the Thousand Island Section, provides 25-foot navigation. Only in a brief distance of 119 miles, from Ogdensburg, N. Y., and Prescott, Ontario, to Montreal, are there obstructions preventing ordinary oceangoing vessels from navigating into the heart of the American Continent. The distance of 1,003 miles from Montreal to the Straits of Belle Isle is navigable by oceangoing vessels. From Montreal to Father Point, a distance of 351 miles, the channels have a minimum depth of 32 feet and are now being deepened to 35 feet. Through the lower St. Lawrence River and the Gulf of St. Lawrence for the remaining 652 miles to open ocean, there is deep-sea navigation.

Even the stretch of 119 miles between Prescott and Montreal is not completely blocked; 70 miles of it is navigable in open waters, 31 miles in Lake St. Francis, and 16 miles in Lake St. Louis, and the rest in the broad and calm stretches of river channels. The remaining 49 miles consist of a succession of rapids; the Galop and the Long Sault Rapids between Prescott and Cornwall, Ontario; the Soulanges Rapids between Lake St. Francis and Lake St. Louis; and the Lachine Rapids from Lake St. Louis to Montreal Harbor. The waters of the St. Lawrence River descend 224 feet over these rapids between Prescott and Montreal. These rapids are interspersed by calm stretches of water which are navigable for vessels up to 14 or 15 feet draft. The rapids themselves are circumvented by canals. Unfortunately these canals, built entirely within Canada and with Canadian capital, have navigable depths of only 14 to 16 feet and are, therefore, inaccessible to deeper draft oceangoing vessels

The principal objective of the St. Lawrence Seaway project is

the improvement of the channels between Prescott and Montreal to admit deep-draft ocean going vessels, thereby creating uninterrupted passage from the Atlantic into the Great Lakes. This is to be accomplished by the construction of dams, locks, and canals at the International Rapids, the Soulanges Rapids and Lachine Rapids, and the dredging of connecting channels. The initial depth will be 27 feet, with locks 30 feet deep over the sills, in order to overcome the difference of 224 feet in the water level between Lake Ontario and Montreal.

In greater detail, the St. Lawrence project first proposes the following changes: A new lock will have to be built at St. Marys River in the same dimensions as proposed for the St. Lawrence, 30 feet over the sills, and the St. Marys River, St. Clair River, and Detroit River will be dredged to 27 feet. The 324-foot drop in the Niagara River has already been overcome by the construction of the Welland Ship Canal which Canada completed in 1932 with an initial depth of 25 feet and locks 30 feet deep. This canal will require deepening to 27 feet. The first 67 miles of the river through the Thousand Island Section to Chimney Point require deepening from 25 to 27 feet.

In the 48 miles of the International Rapids Section, under a so-called "two-stage" or two-dam plan, one dam would be built at Crysler Island (or Ogden Island) and another at Barnhart Island; under a "single-stage" plan, which is now preferred, only one dam would be built—at Barnhart Island—with a control dam farther up the river. This section would require three locks to overcome a drop of 92 feet between Chimney Point and Lake St. Francis. In the wholly Canadian section of the river the required dam has already been built, at the foot of Lake St. Francis, in connection with the Beauharnois power development. This dam will become a part of the new Soulanges Canal development. Provision has been made for the installation of twin flight locks to scale a drop of 83 feet in water levels over the 18 miles between Lake St. Francis and Lake St. Louis. The river drops 48 feet in the Lachine section between the foot of Lake St. Louis and Montreal Harbor, over a distance of 24 miles. Ten miles of canals and three lift locks are necessary to circumvent the Lachine Rapids.

The development of the International Rapids Section is the most important part of the project. The specific geological and engineering factors involved in this project will not here be discussed, as they have been exhaustively treated in previous studies.³ The Board of Engineers is now (December 1940) working on final plans for the development of the project.

A complete description of distance and the nature of the channels in the Great Lakes-St. Lawrence Waterway as now constituted, is

³ Reports of the War Department, *Survey of the Great Lakes-St. Lawrence Seaway and Power Project*, Sen. Doc. 116, 73d Cong., 2d Sess., Vol. 1, pt. 1.

given in detail in table 1. In the 2,351 miles from Duluth to the Atlantic, the proposed Seaway would create unrestricted navigation for 2,276 miles, 8 miles of restricted channels, and a total of 67 miles of canal navigation.

TABLE 1
The existing waterway, from Duluth to the Atlantic Ocean

Location	Minimum water depth (feet)	Number of locks	Number of movable bridges	Time to navigate (hours)	Distance in miles			
					Open water	Restricted channels	Canals	Total
Lake Superior: Duluth to St. Marys River ¹	35			32.0	383			383
St. Marys River:								
Head of river to St. Marys Falls Canal	26			1.2	13			13
St. Marys Falls Canal ²	24½	1	1	1.0			2	2
St. Marys Falls to Point Detour	21			4.1	48			48
Lake Huron: Point Detour to St. Clair River	30			18.3	223			223
St. Clair River	21			3.3	40			40
Lake St. Clair	21			1.5	17			17
Detroit River	21			2.8	31			31
Lake Erie: Detroit River to Welland Canal	27			18.3	218			218
Welland Ship Canal	25	8	20	13.5		2	28	30
Lake Ontario: Welland Ship Canal to St. Lawrence River	27			13.3	159			159
Subtotal: Duluth to St. Lawrence River	21	9	21	109.3	1,132	2	30	1,164
St. Lawrence River:								
Lake Ontario to Ogdensburg	25			5.0	64.0			64.0
Ogdensburg to Galop Canal	15			1.0	4.0	2	1.0	7.0
Galop Canal ³	14	3		3.0			7.3	7.3
Between Galop and Rapide Plat Canals	15			.5	4.5			4.5
Rapide Plat Canals ⁴	14	2		1.7			3.7	3.7
Between Rapide Plat and Farrans Point Canal	15			1.0	9.5			9.5
Farrans Point Canal	16	1		.8			1.3	1.3
Between Farrans Point and Cornwall Canals	15			.5	5.0			5.0
Cornwall Canal	14	6	2	5.2			11.2	11.2
Lake St. Francis	15			3.1	31.0			31.0
Soulanges Canal ⁵	15	5	1	5.3			14.0	14.0
Lake St. Louis	15			1.6	16.0			16.0
Lachine Canal ⁶	14	5	10	4.3			8.5	8.5
Subtotal, Lake Ontario to Montreal	14	22	13	33.0	134.0	2.0	47.0	183.0
Montreal to Quebec	30			13.0	160.0			160.0
Quebec to Father Point	30			16.0	191.0			191.0
Father Point to Strait of Belle Isle	30			54.0	652.0			652.0
Subtotal: Montreal to Strait of Belle Isle	30			83.0	1,003.0			1,003.0
Subtotal: St. Lawrence River	14	22	13	116.0	1,137.0	2	47.0	1,186.0
Total, Duluth to open ocean	14	31	34	225.3	2,269.0	4	77	2,350.0

¹ Alternate route in Lake Superior, used largely during periods of stormy weather in spring and fall, is the Keweenaw Waterway, a lake level canal beginning 163 miles from Duluth. It is 25 miles long, of which 13 miles is open water navigation through Portage Lake, the remaining 12 miles being through restricted channels not less than 150 feet bottom width and 20 feet depth.

² The St. Mary's Falls Canals bypass St. Marys Rapids at Sault Ste. Marie, Michigan and Ontario, with 4 locks side by side in the United States and 1 lock in Canada. Two American locks and approaches thereto have a minimum depth of 24½ feet. One swing bridge crosses the American south canal, 1 bascule bridge crosses the American north canal, and 1 swing bridge crosses the Canadian Canal.

³ The Galop Locks consist of 2 lift locks and 1 guard lock. The upper lift lock passes descending vessels to the river below Galop Rapids thus avoiding 6 miles of canal navigation.

⁴ Descending vessels do not use the Rapide Plat and Farrans Point Canals except during periods of extreme low water.

⁵ The Soulanges Locks consist of 4 lift locks and 1 guard lock.

⁶ The Lachine Locks consist of 5 lift locks.

SOURCE: *Survey of the Great Lakes-St. Lawrence Seaway and Power Project*, Senate Document 116, 73d Cong., 2d Sess., Vol. I, pp. 39-40.

When completed, the condition of the waterway would be as shown in table 2. It is clear from an examination of this table that of the 67 miles of canals, 28 miles would be in the Welland Ship Canal between Lake Erie and Lake Ontario, and 37 miles in four different sections between Lake Ontario and Montreal. The present St. Marys Canal, 2 miles in length, would complete the necessary connecting channels between Lake Superior and the lower St. Lawrence River.

TABLE 2

The proposed deep waterway, from Duluth to the Atlantic Ocean

Location	Minimum water depth (feet)	Number of locks	Number of movable bridges	Distance in miles			
				Open water	Restricted channels	Canals	Total
Lake Superior: Duluth to St. Marys River.....	35			333			333
St. Marys River:							
Head of river to St. Marys Falls Canal.....	28			13			13
St. Marys Falls Canal ¹	28	1	1			2	2
St. Marys Falls to Point Detour ²	27			48			48
Lake Huron: Point Detour to St. Clair River.....	30			223			223
St. Clair River.....	27			40			40
Lake St. Clair.....	27						17
Detroit River ³	27			31			31
Lake Erie to Welland Ship Canal.....	27			218			218
Welland Ship Canal.....	27	8	20		2	28	30
Lake Ontario: Welland Ship Canal to St. Lawrence River.....	27			159			159
Subtotal: Duluth to St. Lawrence River.....	27	9	21	1,132	2	30	1,164
St. Lawrence River:							
Lake Ontario to Chimney Point.....	27			67			67
Chimney Point to East Williamsburg Canal.....	27			23			23
East Williamsburg Canal (Crysler Is.).....	27	1				8	8
East Williamsburg Canal to Grass River Canal.....	27			9			9
Grass River Canal (Barnhart Island).....	27	2	1			7	7
Grass River Canal to Colquhoun Is. Lake St. Francis.....	27			27	6		6
Boulanges-Beauharnois Canal ⁴	27	3	3			18	18
Lake St. Louis.....	27			15			15
Lachine Canal: Lachine to Montreal.....	27	3	4			9	9
Subtotal, Lake Ontario to Montreal.....	27	9	8	141	6	37	194
Montreal to Quebec.....	30			160			160
Quebec to Father Point.....	30			191			191
Father Point to Strait of Belle Isle.....	30			652			652
Subtotal, Montreal to Strait of Belle Isle.....	30			1,003			1,003
Subtotal, St. Lawrence River.....	27	9	8	1,144	6	37	1,187
Total, Duluth to open ocean.....	27	18	29	2,276	8	67	2,351

¹ One new lock 30 feet deep which will be constructed on the American side, replacing 1 of the existing locks.

² Down-bound traffic passes to the west of Neebish Island; up-bound traffic passes to the east of Neebish Island.

³ Down-bound traffic passes to the west of Bois Blanc Island; up-bound traffic passes to the east of Bois Blanc Island.

⁴ Parallel locks in 2 steps are provided at the lower end of this canal. At the upper end is a guard lock.

SOURCE: *Survey of the Great Lakes-St. Lawrence Seaway and Power Project*—Vol. 1, 73d Cong., 2d Sess., Senate Document 116, p. 44.

Section 2

TRAFFIC ON THE PRESENT ST. LAWRENCE CANALS

It is unnecessary to discuss the conditions of navigation on the Great Lakes proper, since this succession of inland lakes is one of the greatest avenues of water transportation in the world today. Less obvious, however, are the navigational conditions in that stretch of the St. Lawrence which lies between Lake Ontario and Montreal. The common picture created by opponents of the seaway is that this section of the river is a tortuous and dangerous stream of water which would be utterly impracticable for navigation. The fact is that even on the restricted 14-foot canals between Lake Ontario and Montreal, there is frequent service and a large amount of traffic.

Table 3 shows the total east- and west-bound tonnage and traffic that has gone through the St. Lawrence canals from 1910 to 1938. These figures, taken from the Dominion Bureau of Statistics of Canada, indicate that since 1930 this through traffic has been more than 5,000,000 tons a year, and of late years, 1937 and 1938, has surpassed 8,000,000 tons a year. In addition to these figures of through traffic just mentioned, the way traffic on the St. Lawrence canals has been in the neighborhood of 1,000,000 tons.

TABLE 3

Through traffic on the St. Lawrence Canals, 1910-38

[Short tons]

Year	West-bound	East-bound	Total	Origin of cargo	
				Canada	United States
1910.....	471,220	1,488,551	1,959,771	1,206,287	753,484
1911.....	534,283	1,792,446	2,326,729	1,315,932	1,010,797
1912.....	567,683	2,085,540	2,653,223	1,579,224	1,073,999
1913.....	671,472	2,815,410	3,486,882	2,095,650	1,391,232
1914.....	625,422	3,067,497	3,692,919	2,117,172	1,575,747
1915.....	567,801	2,297,261	2,865,062	1,536,755	1,328,307
1916.....	568,970	2,404,815	2,973,785	1,243,600	1,730,185
1917.....	411,329	2,614,356	3,025,685	1,044,794	1,980,891
1918.....	346,887	2,394,749	2,741,636	629,037	2,112,599
1919.....	372,824	2,116,464	2,489,288	1,150,156	1,339,132
1920.....	479,829	2,187,174	2,667,003	923,129	1,743,874
1921.....	469,054	2,885,442	3,354,496	1,202,183	2,152,313
1922.....	607,875	2,989,063	3,596,938	2,029,474	1,567,464
1923.....	523,714	3,393,079	3,916,793	2,389,592	1,517,201
1924.....	574,955	4,368,249	4,943,204	3,174,315	1,768,889
1925.....	803,428	4,651,365	5,459,793	3,470,340	1,989,453
1926.....	955,765	4,276,056	5,231,821	3,521,895	1,709,926
1927.....	1,231,182	5,631,473	6,862,655	4,387,341	2,475,314
1928.....	1,211,619	6,109,729	7,321,348	5,103,362	2,217,986
1929.....	1,241,681	3,350,631	4,592,312	3,067,806	1,524,506
1930.....	1,347,046	3,815,974	5,163,020	3,783,523	1,374,492
1931.....	1,403,158	3,799,581	5,202,739	4,005,996	1,196,743
1932.....	1,788,994	4,254,794	6,043,788	5,064,716	979,072
1933.....	2,418,133	3,783,466	6,201,599	4,891,659	1,309,940
1934.....	2,942,432	2,818,395	5,760,827	4,093,010	1,667,817
1935.....	3,158,995	2,707,187	5,866,182	4,010,474	1,855,708
1936.....	3,569,202	3,771,144	7,340,346	5,260,775	2,079,571
1937.....	4,122,037	4,038,358	8,160,395	4,708,032	3,452,363
1938.....	2,687,237	5,597,930	8,285,167	4,911,160	3,374,007

SOURCE: Canada, Dominion Bureau of Statistics, *Canal Statistics*.

To carry the through traffic, more than 5,000 vessel trips have been required, and for way and through traffic combined, the number of vessel passages has been between 9,000 and 10,500, as shown in table 4. This traffic is carried, of course, on ships of 14-foot draft or less. In construction and design these ships are small replicas of the Great Lakes carriers. The daily average through passage has varied between 16 and 24 ships a day. The average way and through traffic combined is more than 40 passages a day. Thus the present St. Lawrence Canal system is by no means an abandoned ship channel, used only infrequently; but on the contrary, it may be considered among the busiest waterways of the North American Continent.

TABLE 4

Traffic and vessel passages on St. Lawrence canals, 1929-38

Year	Through traffic (thousands of short tons)	Way traffic (thousands of short tons)	Total traffic (thousands of short tons)	Season of navigation (days)	Number of vessels carrying through traffic	Total transits, way and through	Average transits per day of vessels carrying through traffic
1929.....	4,592	511	5,103	246	3,930	10,891	16.0
1930.....	5,163	1,016	6,179	244	4,168	9,519	17.1
1931.....	5,203	834	6,037	243	4,259	10,522	17.5
1932.....	6,044	650	6,694	245	4,628	8,171	18.9
1933.....	6,202	749	6,951	236	4,771	9,508	20.2
1934.....	5,861	899	6,660	240	4,434	9,345	18.4
1935.....	5,866	1,007	6,873	238	4,409	10,326	18.5
1936.....	7,340	948	8,288	244	5,023	10,460	20.6
1937.....	8,160	1,035	9,195	239	5,141	10,204	21.5
1938.....	8,265	951	9,236	243	5,898	9,689	24.2

SOURCE: Canada, Dominion Bureau of Statistics, *Canal Statistics*.

An analysis of the type of traffic carried on these canals shows that a major part consists of grain products. In 1938 down-bound traffic in wheat, for instance, accounted for 2,164,661 tons out of a total down-bound movement of 5,597,930, as shown in table 5. Down-bound corn, amounting to 1,575,896 tons, was the next largest item of traffic. Barley was third, and soft coal from American sources was fourth in magnitude, with 524,399 and 508,790 tons respectively. Flour and oats, petroleum and other oils, iron and steel, salt, rye, flaxseed, and coke are other items of importance in down-bound traffic. Up-bound traffic consisted principally of gasoline, petroleum, and other products; sugar, pulpwood, wood pulp, hard coal, soft coal, iron ore, flaxseed, and paper.

The major part of this through traffic on the St. Lawrence canals is transhipped at Montreal, for the west-bound trip from oceangoing vessels to canal boats. On the east-bound trip, cargoes are transferred from Lake vessels to canal boats at such centers as Buffalo,

Port Colborne, Kingston, and Prescott, on the Lakes and upper St. Lawrence River, and then again at Montreal from canal boats to oceangoing vessels.

TABLE 5

Through traffic on the St. Lawrence canals during open navigation, 1938

[Tons of 2,000 pounds]

Commodity	Up-bound	Down-bound	Commodity	Up-bound	Down-bound
Barley.....	168	524, 399	Paper.....	64, 883	2, 458
Corn.....	1, 775	1, 575, 896	Wood pulp.....	203, 696	-----
Oats.....	-----	106, 508	Pulpwood.....	515, 291	33
Rye.....	-----	66, 896	Firewood.....	4, 600	-----
Flaxseed.....	22, 820	11, 076	Lumber, mill and cooperage stock.....	2, 623	-----
Wheat.....	1, 350	2, 164, 661	Hard coal.....	289, 184	-----
Other grains.....	-----	58, 003	Soft coal.....	89, 327	508, 790
Flour.....	-----	121, 777	Coke.....	64, 850	23, 562
Other mill products.....	-----	19, 531	Copper ore.....	2, 700	-----
Fruits and vegetables.....	150	7, 985	Iron ore.....	113, 752	-----
Other packing-house products.....	-----	150	Other ore.....	23, 268	1, 794
All other animal products.....	-----	2, 413	Sand, gravel, and stone.....	-----	2, 518
Gasoline.....	450, 109	17, 588	All other freight.....	324, 068	-----
Petroleum and other oils.....	357, 610	53, 779	Total.....	2, 687, 237	5, 597, 930
Agricultural implements.....	-----	4, 817	Grand total, up- and down-bound.....	8, 285, 167	-----
Iron, pig, and bloom.....	-----	6, 895	Origin of cargo:	-----	-----
Iron and steel, other.....	19, 278	44, 155	United States ¹	3, 374, 007	-----
Sugar.....	140, 035	10	Canada.....	4, 911, 160	-----
Salt.....	1, 430	31, 350			
Beverages.....	4, 340	1, 834			
Autos and parts.....	-----	14, 087			

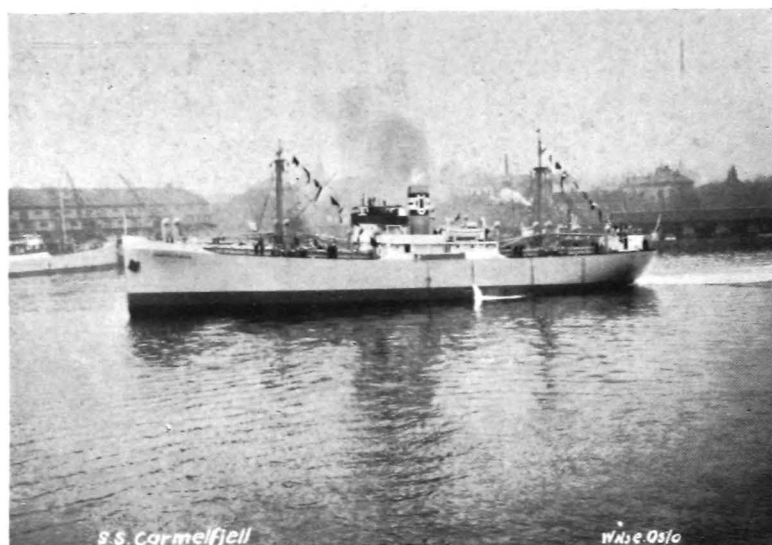
¹ Canada, *Canal Statistics*, 1938, page 6: "By far the greater part of the traffic using the Canadian canals is from and to Canadian or United States ports, but in recent years a considerable amount of freight has been brought up the canals and Great Lakes from European ports and a lesser amount has been shipped out direct to trans-Atlantic ports. For convenience, such freight has been included with freight to and from United States ports.

Source: Canada: Dominion Bureau of Statistics, *Canal Statistics*, 1938, pp. 40-41.

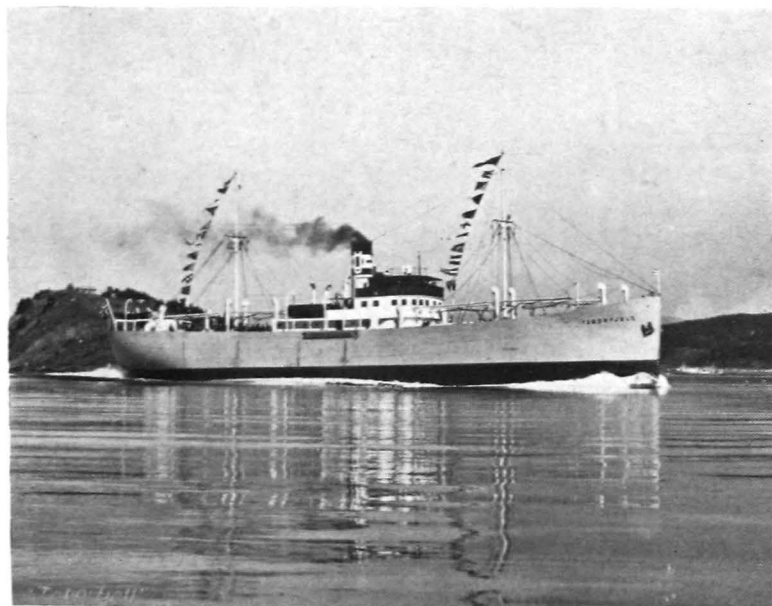
Since 1933, there has been through service from Great Lakes ports to overseas destinations on ships of 14-foot draft or less, which have been constructed especially for this uninterrupted traffic. The ships in this service are principally of Norwegian, Dutch, and Canadian registry.

In 1938, 58,418 long tons of freight were exported in these light-draft oceangoing vessels directly from the United States to Scandinavian countries and north German ports. There was even a departure direct to Black Sea ports. In the same year, 56,952 long tons were imported to the Great Lakes in these same vessels from the United Kingdom, Baltic, Scandinavian, and north German ports, and one vessel from the Caribbean.

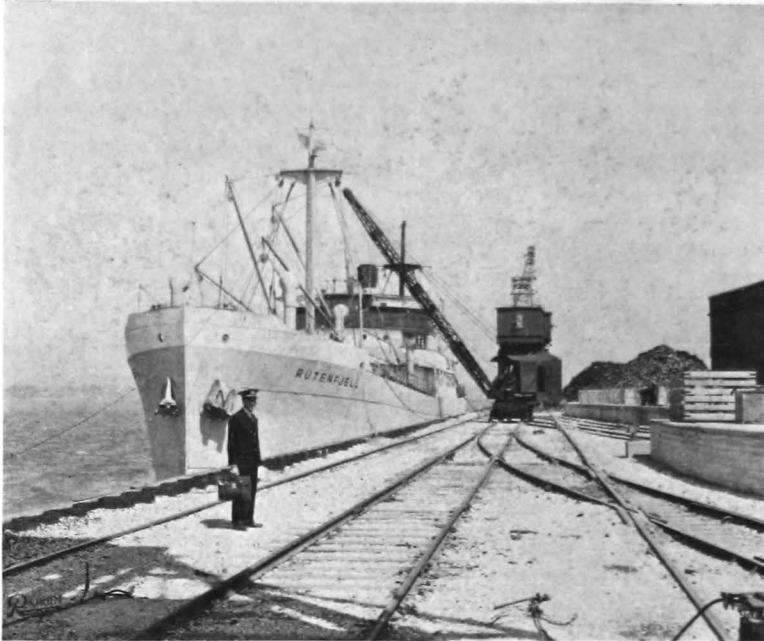
The type of traffic carried in-bound on these trips consisted principally of wood pulp, paper, animal, fish, and dairy products, nonmetallic minerals, ores, paper stock, etc.; and out-bound traffic consisted of grains and grain products, animal feeds and fodder, vehicles, medicine, drugs and toilet preparations, coal and coke, iron and steel, etc. Through exports and imports in 1938 are shown in detail in tables 6^a and 6a. The 3-year totals, 1937-39, are shown in table 7.



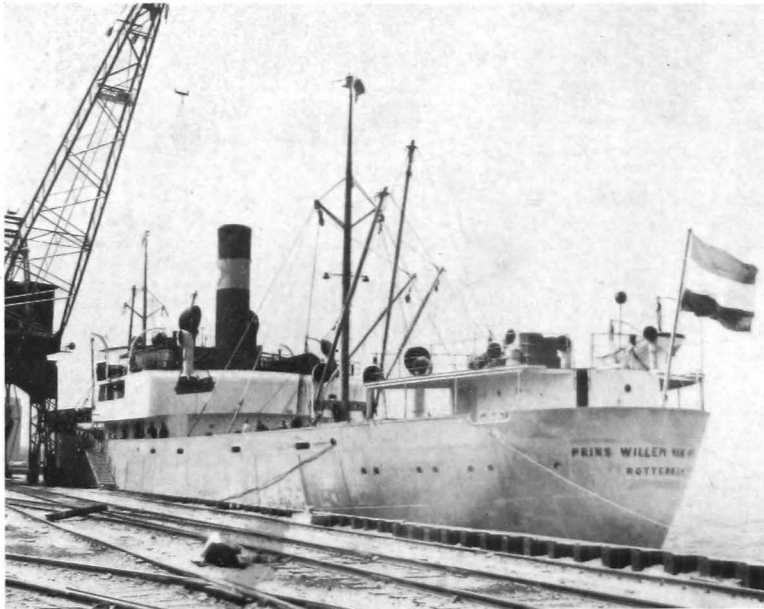
S. S. *Carmelfjell*. Built in 1935. Gross tonnage, 1,334; net tonnage, 716; dead-weight tonnage, 2,650; length, 258 feet; width, 41 feet; draft, 17 feet 6½ inches; grain cubic, 166,000; bale cubic, 155,000; speed, 11 knots.



S. S. *Taborfjell* of the Fjell Line. Built in 1938. Length, 250 feet 9 inches; width, 41 feet 3 inches; draft, 17 feet 6 inches; gross tonnage, 1,339; net tonnage, 742.



Fjell Line Steamer *Rutenfjell* being loaded at dock of West Michigan Dock and Market Corporation, Muskegon, Mich. Built in 1935. Length, 250 feet 9 inches; beam, 41 feet 3 inches; depth, 17 feet; gross tonnage, 1,334; net tonnage, 718; deadweight tonnage, 2,400.



Oranje Line Steamer *Prins Willem Van Oranje* of Rotterdam unloading hides by Gantry crane operation in lieu of ship's tackle, at Muskegon, Mich. Built in 1938; length, 250 feet 4 inches; breadth, 42 feet 2 inches; draft, 14 feet; gross tonnage, 1,303; net tonnage, 696.

TABLE 6

United States exports through the St. Lawrence canals to overseas countries, 1938

[In cargo tons of 2,240 pounds]

Commodity	To—				Total
	United Kingdom	Baltic Scandinavia	Bayonne, Hamburg	Mediterranean and Black Sea	
Animal, fish, and dairy products, edible.....	966		26		992
Oils, animal, fish, and vegetable.....			212		212
Animal products, inedible.....	192	48	17		255
Grain, linseed, soybean bulk.....		3,070			3,070
Grain products, dry.....	1,151	2,043			3,194
Animal feeds and fodder.....	2,976	1,380	11,920		16,276
Fruits and vegetables.....	91				91
Sugar and molasses.....	240	77			317
Seeds and nursery stock.....	74		168		242
Rubber, except rubber goods.....	51				51
Naval stores.....			2,984		2,984
Wool and hair.....	124				124
Lumber.....	1,356	17	20		1,393
Wood pulp.....	2				2
Paper stock.....	2		10		12
Paper.....	44				44
Coal and coke.....		1,953		1,154	3,107
Petroleum and products.....	1,032		278		1,310
Asphalt and pitch.....			1,428		1,428
Clay, chalk, stone, sand, and cement.....	824	34	170		1,028
Nonmetallic minerals.....		30	3		33
Ores.....	2	10	47		59
Iron and steel.....	4,773	119	1,672		6,564
Metal scraps.....	526	90	640		1,256
Metals, n. e. s. (not iron or steel).....	31		91		122
Machinery, heavy.....	2,233	60	39		2,332
Vehicles.....		3,760	40		3,800
Machines, small, and appliances.....	10				10
Rubber goods.....		17			17
Manufactured goods.....	112	166	20		298
Building materials, n. e. s.....			20		20
Medicines, drugs, and toilet preparations.....	23				23
Chemicals.....	650	4,166	226		5,042
Paints and pigments.....	26	35	10		71
Fertilizer, n. e. s.....	900				900
Returned containers.....	40	155	48		243
Miscellaneous.....	607	327	562		1,496
Total.....	19,058	17,555	20,651	1,154	58,418

SOURCE: U. S. Maritime Commission, Division of Research.

TABLE 6a

United States imports through the St. Lawrence canals from overseas countries, 1938

[In cargo tons of 2,240 pounds]

Commodity	From—				Total
	United Kingdom	Baltic Scandinavia	Bayonne, Hamburg	Caribbean	
Animal, fish, and dairy products, edible.....	1	2,443	18		2,462
Hides and skins.....	32		392		424
Oils, animal, fish, and vegetable.....		1,475	50		1,525
Animal products, inedible.....		7			7
Grain, linseed, soybean, bulk.....	6				6
Grain products, dry.....		1	1,301		1,302
Animal feeds and fodder.....	5	427			432
Fruits and vegetables.....	13	4	241		258
Coffee and cocoa.....			10		10
Sugar and molasses.....				1,510	1,510

TABLE 6a

United States imports through the St. Lawrence canals from overseas countries, 1938—Continued

[In cargo tons of 2,240 pounds]

Commodity	From—				Total
	United Kingdom	Baltic Scandinavia	Bayonne, Hamburg	Caribbean	
Beverages	190	6	1,833		2,028
Teas and spices	54		529		583
Seeds and nursery stock			1,034		1,034
Tapioca and other starches			50		50
Miscellaneous vegetable products, inedible		7			7
Textiles	1		38		39
Fibers and products	668		1,150		1,818
Wood-pulp		24,402	1,038		25,440
Paper		2,248	1		3,249
Clay, chalk, stone, sand, and cement	5,267	40	71		5,378
Nonmetallic minerals		1,510	1,350		2,860
Ores		1,475	1,225		2,700
Iron and steel		243	347		590
Metals n. e. s. (not iron or steel)			295		295
Machinery, heavy		7	1		8
Glass, porcelain, earthenware			19		19
Manufactured goods			107		107
Building materials, n. e. s.		20	122		142
Chemicals		81	155		236
Paints and pigments	15		800		815
Fertilizers, n. e. s.		466			466
Moss and kelp		229	225		454
Miscellaneous	90	42	566		698
Total	6,342	36,132	12,968	1,510	56,952

SOURCE: U. S. Maritime Commission, Division of Research.

To carry this traffic, 215 in-bound and 182 out-bound trips were made to overseas points in 1937, 1938, and 1939. In addition to this through traffic to European points, there is considerable direct service between American Great Lakes ports and eastern maritime Provinces of Canada and Newfoundland. The extent of this traffic and the number of trips involved are shown in table 8.

TABLE 7

Movement of traffic through the St. Lawrence canals to and from European points, 1937-39

[Tons of 2000 pounds]

Year	To Great Lakes ports		From Great Lakes ports	
	Number of trips	Tons carried	Number of trips	Tons carried
1937	52	70,056	35	50,800
1938	60	81,463	59	99,100
1939	103	159,296	88	130,338
Total	215	310,815	182	280,238

SOURCE: Special tabulation furnished by the Dominion Bureau of Statistics, Transportation and Public Utilities Branch, Ottawa, Ontario.

TABLE 8

Movement of traffic through the St. Lawrence canals to and from Atlantic coast points, 1937-39¹

[Tons of 2,000 pounds]

Year	To Great Lakes ports		From Great Lakes ports	
	Number of trips	Tons carried	Number of trips	Tons carried
1937	126	291,725	31	45,836
1938	70	135,323	40	52,080
1939	64	137,908	56	97,627
Total	260	564,956	127	195,543

¹ Principally between Maritime Provinces of Canada and Newfoundland, and Great Lakes ports.

Source: Special tabulation furnished by the Dominion Bureau of Statistics, Transportation and Public Utilities Branch, Ottawa, Ontario.

Section 3

CONDITIONS OF NAVIGATION ON THE ST. LAWRENCE RIVER

It is clear from the foregoing discussion that the St. Lawrence Seaway project is no new venture. The river is already a much traveled highway of commerce. In spite of this, however, much criticism has been directed against the project on the grounds that oceangoing ships would not or could not effectively use the St. Lawrence Seaway even if it were deepened to 27 feet, thus opening the Great Lakes to direct waterborne traffic with the rest of the world.

The claim is made that the open season of navigation through the St. Lawrence into the Great Lakes would be too short for profitable ocean shipping to be established. One estimate is that "the practical season of navigation for ocean vessels would be limited to about 6½ months."⁴ This prediction is made on the theory that ocean ships going into the Great Lakes must reckon with the earliest probable closing date of shipping at Montreal, and must allow sufficient time for the round trip into the Great Lakes so that they will be able to clear from Montreal by the time navigation may be closed. In order to permit time for the round trip into the Lakes, it is stated that the last boat to leave Montreal for Lake Superior ports, with the intention of returning, must leave Montreal 10 or 12 days before the earliest probable closing date of navigation, which is estimated to be November 25. This means that the latest proposed round-trip journey must start out of Montreal about November 5 or 6.

⁴ Harold G. Moulton, C. S. Morgan and A. L. Lee, *The St. Lawrence Navigation and Power Project*, to Brookings Institution, 1929, p. 62.

By a similar analysis of opening dates of navigation, it is stated that incoming ships at the beginning of the season can reckon upon free navigation beginning with May 1, although during many seasons Montreal Harbor is free for ocean shipping earlier than this date. On such analysis it is concluded, "thus the actual season of navigation would extend from about May 1 until about the middle of November, or 6½ months."⁵ An analysis of the experience on the Great Lakes and at Montreal during the past 20 years indicates that this conclusion is utterly unacceptable.

Tables 9, 10, and 11 give the opening and closing dates of navigation, and the number of days of navigation during the open season, at St. Marys Falls Canal, at the Welland Ship Canal, the St. Lawrence Canals, and the Port of Montreal, from 1920 to 1939. From table 9 it is clear that on the St. Marys River, which connects Lake Superior with the lower lakes, and where one lock is provided to scale the difference in the levels of Lake Superior and Lake Huron, the average season of navigation has been 243 days, or approximately 8 months, during those 20 years.

TABLE 9
Season of navigation on the St. Marys Falls Canal

Year	Opening of navigation	Closing of navigation	Days open	Year	Opening of navigation	Closing of navigation	Days open
1920	Apr. 19	Dec. 26	253	1930	Apr. 21	Dec. 15	239
1921	Apr. 7	Dec. 24	262	1931	Apr. 10	do	250
1922	Apr. 17	Dec. 20	248	1932	Apr. 17	Dec. 13	241
1923	May 1	Dec. 17	231	1933	Apr. 19	Dec. 14	240
1924	Apr. 19	Dec. 19	245	1934	Apr. 29	Dec. 15	231
1925	Apr. 10	Dec. 16	251	1935	Apr. 16	Dec. 16	245
1926	Apr. 29	Dec. 18	234	1936	Apr. 29	do	232
1927	Apr. 13	Dec. 16	248	1937	Apr. 8	Dec. 15	252
1928	May 3	Dec. 15	227	1938	Apr. 12	do	248
1929	Apr. 13	Dec. 14	246	1939	Apr. 26	do	234
				Average	Apr. 19	Dec. 17	243

SOURCE: *Statistical Report of Lake Commerce Passing Through Canals at Sault Ste. Marie, 1920-39*, Corps of Engineers, United States Army.

Further examination of table 9 shows that the latest date of the opening of navigation on the St. Marys River was May 3, 1928, and the earliest date of closing was December 13, 1932. Generally, the season has extended from the last week of April to the second week of December. Taking the latest date of opening during these 20 years, May 3, 1928, and the earliest date of closing, December 13, 1932, the least probable length of the season of navigation appears to be about 7½ months, or 225 days.

⁵ *Ibid.*, p. 63.

Table 10 gives data on the season of navigation through the Welland and St. Lawrence Canals during the years 1920 to 1939. It shows that the latest date of opening of the Welland Canal was May 1, 1926, and the earliest date of closing, December 9, 1929. Taking the number of days between the latest date of opening and the earliest date of closing, although they occurred in different years, the least probable length of the season during those 20 years was 223 days. The average for those 20 years was 245 days.

TABLE 10

Seasons of navigation at Welland and St. Lawrence Canals, 1920-39

Year	Welland Canal			St. Lawrence canals		
	Opening of navigation	Closing of navigation	Days open	Opening of navigation	Closing of navigation	Days open
1920.....	Apr. 19	Dec. 15	241	May 1	Dec. 11	225
1921.....	Apr. 15	Dec. 19	249	Apr. 18	Dec. 14	241
1922.....	Apr. 17	Dec. 14	242	Apr. 19	Dec. 11	236
1923.....	do.	do.	242	May 1	Dec. 10	224
1924.....	Apr. 16	Dec. 10	239	Apr. 21	Dec. 11	234
1925.....	Apr. 14	Dec. 17	248	Apr. 23	do.	233
1926.....	May 1	Dec. 15	229	Apr. 29	Dec. 5	221
1927.....	Apr. 16	Dec. 16	245	Apr. 18	Dec. 14	241
1928.....	do.	Dec. 13	242	Apr. 16	Dec. 10	239
1929.....	Apr. 17	Dec. 9	237	Apr. 11	Dec. 12	246
1930.....	Apr. 21	Dec. 12	236	Apr. 12	Dec. 11	244
1931.....	Apr. 9	Dec. 17	253	Apr. 17	Dec. 12	243
1932.....	Apr. 7	Dec. 16	255	Apr. 14	Dec. 15	245
1933.....	Apr. 4	Dec. 13	254	do.	Dec. 5	236
1934.....	Apr. 17	Dec. 15	243	Apr. 18	Dec. 13	240
1935.....	Apr. 1	Dec. 20	264	Apr. 22	Dec. 15	238
1936.....	Apr. 17	Dec. 13	241	Apr. 17	Dec. 16	244
1937.....	Apr. 10	Dec. 12	247	Apr. 12	Dec. 6	239
1938.....	Apr. 11	Dec. 15	249	Apr. 16	Dec. 14	243
1939.....	Apr. 10	Dec. 16	251	Apr. 25	Dec. 11	231
Average.....	Apr. 14	Dec. 15	245	Apr. 19	do.	237

SOURCE: Canada, Dominion Bureau of Statistics, *Canal Statistics*.

Similarly, on the St. Lawrence canals, May 1, 1920 and 1923, were the latest dates of opening, and December 5, 1926, was the earliest date of closing. The least probable length of the season appears to have been 219 days, although the average for the 20-year period was 237 days.

At Montreal the latest date of arrival of ocean vessels was May 3, 1923 and 1926, and the earliest date of closing was December 1, 1923, as shown in table 11. Here the least probable number of days for ocean navigation appears to be 213 days between May 3 and December 1, or slightly more than 7 months.

Assuming that the trip from Duluth to Montreal would take 5 or 6 days, a departure from Duluth as late as November 25 would have allowed ample time for the ship to clear through Montreal, with no danger of being frozen in, during any one of these 20 seasons. Simi-

larly, at the opening of the season, a transit timed to clear Montreal on the way to the Great Lakes by May 3 at the latest would have prevented any possible delays on the trip. If the shipping line would permit itself to run the risk of 1 out of 10 chances of being delayed at Montreal, a trip could be timed to clear out of Montreal as early as April 29.

TABLE 11

Dates of first arrival and last departure of ocean boats at Montreal Harbor, 1920-39

Year	Date of arrival of first ocean boat	Date of departure of last ocean boat	Year	Date of arrival of first ocean boat	Date of departure of last ocean boat
1920	Apr. 25	Dec. 11	1930	Apr. 21	Dec. 12
1921	Apr. 21	Dec. 8	1931	Apr. 15	Dec. 11
1922	Apr. 24	Dec. 2	1932	Apr. 18	Dec. 7
1923	May 3	Dec. 1	1933	Apr. 14	Dec. 6
1924	Apr. 24	Dec. 3	1934	Apr. 26	Dec. 8
1925	Apr. 16	Dec. 8	1935	Apr. 15	Dec. 9
1926	May 3	Dec. 6	1936	Apr. 13	Dec. 11
1927	Apr. 12	Dec. 6	1937	Apr. 19	Dec. 8
1928	Apr. 26	Dec. 9	1938	Apr. 18	Dec. 4
1929	Apr. 20	Dec. 7	1939	Apr. 29	Dec. 9
			Average	Apr. 21	Dec. 7

SOURCE: National Harbour Board, Montreal Harbour, Montreal, Quebec.

It may be said without reservation that incoming ships can plan to find unobstructed passage from Montreal Harbor into the St. Lawrence at the latest on May 3, more often by April 26, and from Duluth to Montreal by leaving the head of the Lakes at the latest on or about November 25. If other stops are to be made on the way down, additional time must be allowed.

Incoming cargo ships, therefore, can be expected at Lake Erie ports at the latest on May 6, and at Lake Michigan and Lake Superior ports, May 8. Outgoing shipments may be planned from Lake Superior and Lake Michigan ports as late as November 25, and Lake Erie ports as late as November 27.

The estimate of 6½ months of open navigation cited above is given as a condition which the shipowner must reckon with. This is clearly an erroneous conception, since the shipowner's problem is the number of days during the year that the ships will be operating with revenue-producing cargo, which in this case is not determined by the number of days of free navigation on the Great Lakes, but by the number of actual days en route from the port of origin in foreign lands or in coastwise trade to port of destination in similar distant ports on the return trip.

A ship coming from England, for instance, may take 12 or 14 days to cross the Atlantic, the Gulf of St. Lawrence, and the St. Lawrence

River to Montreal. If it plans to traverse Montreal Harbor about May 3, it must start from its origin as early as April 17 or 19. If it wishes to take the risk of 1 out of 10 chances of being delayed at Montreal, it may start out of North European ports as early as April 10, 11, or 12.

Similarly, a ship leaving Duluth or Chicago as late as November 25 with the intention of clearing out of Montreal by December 1 must look forward to continuing on its journey for another 2 weeks until it reaches its destination in Great Britain, where it would arrive about the middle of December. Hence the actual operating period of a ship between British ports and the Great Lakes would be at least between April 15 and December 15, which is about 8 months of actual operation. The idle period, therefore, would be at the most 4 months. If one allows a month out of every year for repairs and reconditioning, the idle period for the ship would be only 3 months, when new routes or uses must be found for those ships. For ports in the Mediterranean, in South America, or in the Orient, the actual period of operation would be longer than 8 months and the idle period correspondingly less.

The earliest dates of arrival in the Great Lakes and the latest dates of departure from the Great Lakes are of greater interest to the manufacturers and shippers who contemplate using this means of transportation. They must plan their operations according to the schedule of receipts of materials and shipment of goods. The hiatus created by the navigation season for these people would be approximately November 25 to May 6.

For ships operating between British ports and the Great Lakes, the period of idleness, allowing for 1 month of repairs and reconditioning, is estimated to be about 3 months, or 90 days. For ships operating between Mediterranean ports this idle period would probably be 80 days. For ships operating between the Great Lakes and South American ports, Brazil, and the Argentine, the round trip to and from Montreal would take almost 45 days at 10 nautical miles an hour, which would reduce the idle period for the ships to 2½ months during the year, if a month is allowed for repairs and reconditioning. To Far Eastern ports the idle period would be reduced to 1½ months a year.

The opponents of the project have grossly exaggerated the ship-owner's problem in coping with the navigation season on the Great Lakes by describing ice hazards in Great Lakes navigation. They have made extreme generalizations based on exceptional cases. For instance one of the opponents of this project has relied upon the annual report of the Lake Carriers' Association for 1926, which described the very severe ice conditions both at the beginning and at the close of

the season of 1926, which admittedly was "the worst and most prolonged blockade Lake Erie has known for 50 years."⁶ Obviously it is not possible to establish average conditions by referring to the worst possible experience in 50 years.

Furthermore, these opponents have failed to distinguish between the shipper's problem and the shipowner's problem. As shown above, the Great Lakes service provides a longer period of revenue producing operations for the shipowner than is conceded by these writers. This exaggeration is due to the fact that they have not allowed for the time of navigation on the high seas before arrival at Montreal at the beginning of the season, and after departure from Montreal at the end of the season. What they considered the problem of the shipowner is really the problem of the merchants and manufacturers who will utilize the St. Lawrence route. This difficulty must be treated specifically with regard to each type of commodity that may utilize this route.⁷

Section 4

TIME OF PASSAGE OVER THE ST. LAWRENCE SEAWAY

It is said that due to the length of canals and restricted channels in the St. Lawrence route ships would have to operate between Montreal and Lake cities at about three-quarters of their normal rate of movement.⁸

Delayed movement, it is claimed, is involved both in the passage through the locks and in navigating the canals and restricted channels. The total length of canals between Montreal and Duluth would be 53.6 miles of canals, and 150 miles of channel navigation. The canals would be located, according to this version, as follows: 25 miles in the St. Lawrence River, with 8 or 9 locks; 26.75 miles through the Welland Canal, with 7 locks; 1.9 miles through the St. Marys Falls Canal at the Soo, with 1 lock. Channel navigation is said to be required over 67 miles through the Thousand Island section of the International Boundary; and over the Detroit River, between Lake St. Clair and Lake Erie, 32.3 miles; the St. Clair River between Lake Huron and Lake St. Clair, 40 miles; and the St. Marys River, exclusive of the Sault Ste. Marie Canal connecting Lake Superior with Lake Huron, 61 miles.

Critics allow 1 hour for passage through each lock, of which there would be 16 or 17, depending on whether the development in the International Rapids section is one- or two-stage. Navigation through the 53.6 miles of canals is said to require a reduced speed of

⁶ Moulton et. al. *Op. Cit.*, p. 64.

⁷ See Part III.

⁸ Moulton et al. *Op. Cit.*, p. 67.

4 miles an hour, and navigation through the so-called restricted channels is supposed to require a reduced speed of 8 miles an hour. As a result of these delays, a round-trip from Montreal to Duluth is supposed to involve a lengthening of the trip over normal speeds of 74 hours.⁹

Let us now look at the character of the so-called restricted channels and the regulations that apply to operating speeds. Let us also examine the actual experience in passage through these canals.

Table 12 indicates the average length of time it has taken ships to pass through the St. Marys Falls Canal, and the time spent in lockage at Sault Ste. Marie. This canal is 1.9 miles in length. The average time it has taken for ships during the 20 years, 1920-39, to pass this canal, including lockage, was 1 hour and 7 minutes. In some years, such as 1931 and 1932, the average time was fractionally less than an hour. As for the actual time spent in making a lockage, the average for these 20 years has been 31 minutes and 50 seconds. The speed limit allowed within the St. Marys Falls Canal is 2½ miles per hour, and 6 miles per hour on leaving the locks. As for the St. Marys River, the maximum speed permitted by regulations is 10 miles per hour in certain sections, and 12 miles per hour in other sections. Hence, in this stretch of 63 miles between Lake Superior and Lake Huron, the speed that must be assumed is not 8 miles per hour, but at least 10 miles per hour, and in most places 12 miles per hour.

TABLE 12
Time spent in St. Marys Falls Canal

Year	Total time elapsed		Average time spent in making lockage		Year	Total time elapsed		Average time spent in making lockage	
	Hr.	Mfn.	Mfn.	Sec.		Hr.	Mfn.	Mfn.	Sec.
1920	1	15	34	5	1930	1	0	29	10
1921	1	7	31	49	1931	--	56	28	40
1922	1	14	23	26	1932	--	59	26	47
1923	1	29	36	11	1933	1	6	31	10
1924	(¹)	(¹)	31	19	1934	1	9	30	57
1925	1	9	31	43	1935	1	4	32	54
1926	1	11	22	37	1936	1	12	35	10
1927	1	2	30	22	1937	1	12	33	55
1928	1	4	31	12	1938	1	3	31	13
1929	1	2	31	9	1939	1	9	32	50
					Average	1	7	31	50

¹ Not available.

SOURCE: *Statistical Report of Lake Commerce Passing Through Canals at Sault Ste. Marie, 1920-39*, Corps of Engineers, United States Army.

⁹ Moulton et al., *Op. CW.*, p. 68.

In the St. Clair and Detroit Rivers the maximum speed permitted is 12 miles per hour, except in the upper end of the St. Clair River where the speed must not exceed 9 miles per hour.¹⁰

At the rate of an hour per lockage and 4 miles per hour in the canal, it would take 13½ hours to go through the Welland Ship Canal. This is the position taken by critics of the seaway. It is an assumption completely unsupported by regulations applicable to the Welland Canal, nor does it describe actual experience. The maximum speed for vessels not exceeding an over-all length of 260 feet traversing the Welland Ship Canal is 8 miles per hour, and for all other vessels, 6 miles per hour.¹¹ The average time of passage through the Welland Canal is much shorter than assumed by the critics. In 1932, the first year of the operation of the Welland Canal, records were kept of certain fast transits. This is presented in table 13. It appears therefrom that small ships were able to go through in a little over 6 hours, and large ships, in 7 to 9 hours.

TABLE 13

Fast down-bound transits, Welland Ship Canal, 1932

Name	Date	Keel length	Beam	Draft	Cargo	Time
		<i>Feet</i>	<i>Feet</i>	<i>Ft. In.</i>	<i>Tons</i>	<i>Hr. Min.</i>
S. S. Edgewater.....	Nov. 10	288	43	10	1,850, salt.....	6 17
S. S. Noronic.....	Sept. 11	362	52	17 6	Passengers.....	6 27
S. S. Conneaut.....	Aug. 22	416	56	15 6	3,151, coke.....	6 43
S. S. Midland Prince.....	Aug. 28	466	55	15 6	4,000, coke.....	7 22
S. S. Diamond Alkali.....	Oct. 11	504	56	18	8,800, coal.....	7 49
S. S. Thunder Bay Quarries.....	Oct. 2	504	56	14 6	6,000, coke.....	7 16
S. S. Gleneagles.....	Nov. 29	574	60	19 6	12,660, coal.....	7 9
S. S. Lemoyne.....	Sept. 12	613	70	18	14,460, wheat.....	9 13

SOURCE: *The Welland Ship Canal, 1913-33*, Maj. P. J. Cowan, M. B. E., M. Inst. C. E., M. I. Mech. E. A reprint of articles in "Engineering," 1929, 1930, and 1931.

The average time of lake carriers during the 1940 season, until September 30, was: Up-bound, 8 hours and 16 minutes; down-bound, 9 hours and 8 minutes. The average time of passage of canal boats was: Up-bound, 7 hours and 54 minutes; down-bound, 8 hours and 24 minutes.

The average time spent in lockage is also much less than assumed by the critics. For the 1940 season, boats spent an average of 28 minutes in passing through No. 1 lock. This is a single lock located at Port Colborne on the Lake Erie end of the canal. It accommodates both up-bound and down-bound traffic, and involves greater delays than the twin locks, Nos. 4, 5, and 6, at Thorold, Ontario. At No. 1 lock it took 20 minutes for a single lockage, 30 minutes for a double

¹⁰ *Rules and Regulations Relating to the Navigable Waters of the United States*, revised to January 1, 1939, Corps of Engineers, United States Army, pp. 354-359.

¹¹ *Rules and Regulations, Canals of the Dominion of Canada*, Department of Transport, Ottawa, 1937, p. 40, par. 119.

lockage, and 40 minutes for a triple lockage. Of course the average time of lockage varies with each type of boat. The Superintending Engineer of the Welland Canal made special studies, and reports the following average results for different types of vessels:¹²

Time of multiple lockages in lock No. 8 Welland Ship Canal

Number and class of vessels	Time from entering to leaving lock	
	Average time for each vessel	Time from first vessel entering to last vessel leaving
Single lockage:	<i>Minutes</i>	<i>Minutes</i>
Lower canaler.....	17	17
Upper laker.....	19	19
S. S. <i>Lemoyne</i>	30	30
Double lockage:		
2 lower canalers.....	23	30
1 upper laker and 1 lower canaler.....	26	34
2 upper lakers.....	31	34
Triple lockage: 3 vessels.....	29	41

The letter accompanying this study explains that the S. S. *Lemoyne* is the largest lake carrier in operation and in passing through the canal it requires special precautions:¹³

You will note that the list gives information with respect to lower canalers which are vessels of limiting size required for transiting the Ontario and Quebec Canals, upper lake freighters and for the S. S. *Lemoyne*. The S. S. *Lemoyne* has an over-all length of 633 feet, beam 70 feet, molded depth 29 feet, and a carrying capacity of 530,000 bushels of wheat with a draft of 19 feet 6 inches and is the largest freighter on the Great Lakes. This vessel moves much slower than any other vessel as its captain, who is very cautious, contends that increase in speed would be hazardous as his vessel is much more difficult to handle than other vessels. The 70-foot beam of the S. S. *Lemoyne* in a lock 80 feet wide is undoubtedly a factor that adds to the time of lockage for this vessel.

The experience at the Welland Ship Canal is described in detail in the following communication from Mr. C. W. West, Superintending Engineer of the Canal:¹⁴

The first question of Mr. N. R. Danielian, Director, St. Lawrence Waterway Survey, is: "What is the average time of passage up-bound and down-bound through the Welland Ship Canal for the past 5 years?" The time taken by an upper lakes type vessel to pass through the Canal between lock No. 1 (Lake Ontario) and lock No. 8 (Lake Erie) varies between 6½ and 12

¹² Department of Transport, Ottawa, letter to N. R. Danielian, Director, St. Lawrence Survey, November 7, 1940.

¹³ *Ibid.*

¹⁴ Letter from C. W. West, Superintending Engineer, Welland Canals, St. Catharines, Ontario, under date of October 29, 1940, to E. B. Jost, General Superintendent of Canals, Department of Transport, Ottawa.

hours, depending on the captain. Some captains are extremely cautious and travel at exceedingly low speeds. The average time of passage for an upper lakes type vessel during the present navigation season to September 30 was, up-bound, 8 hours and 16 minutes; down-bound, 9 hours and 8 minutes.

Although the St. Lawrence Canal sized vessels (that is, a canaler or vessel not exceeding 260 feet in length) are permitted a speed of 8 miles per hour, they, on many occasions, travel behind upper lakers. Regulation 110 (3) stipulates "No vessel of any size shall attempt to overhaul a vessel exceeding 260 feet in length and no vessel exceeding 260 feet in length shall attempt to overhaul any other vessel." Therefore, in such cases the smaller vessels frequently have to keep to the slower speed of the larger vessels. The average time of passage of a canaler during the 1940 navigation season up to September 30 was, up-bound, 7 hours and 54 minutes; down-bound, 8 hours and 24 minutes.

Mr. Danielian's second question is: "The speed permitted a boat in passing through the Welland Ship Canal." The maximum speed permitted in the canal for a vessel not exceeding 260 feet in length is 8 miles per hour. For vessels exceeding 260 feet in length, the maximum speed is limited to 6 miles per hour.

The third question of Mr. Danielian is: "The average time spent in making a lockage." For the season of 1940 to the end of September, the average time of lockage of a vessel in lock No. 1 was 28 minutes, and the average time of lockage in the guard lock No. 8 was as follows: Single lockage, 20 minutes; double lockage, 30 minutes; triple lockage, 40 minutes; quadruple lockage, 48 minutes.

Mr. Danielian should be told that locks Nos. 4, 5, and 6 are twin locks in flight, whereas all the other locks are single locks. The single locks have to accommodate both up-bound and down-bound traffic, and even if the traffic happens to be all one way, say up-bound, after the vessels have made their exit from a lock, the water level has to be lowered from upper pool level to lower pool level before other vessels following can enter the lock. Therefore, vessels are frequently held back so that their dispatch between locks will coordinate with lockages and vessel movements.

Lock No. 8 is the guard lock at Lake Erie where the head is the difference between the maintained elevation of about 569 for the water level in the long reach and the elevation of the varying level of Lake Erie at Port Colborne, which fluctuates between a minimum elevation of about 569 to a maximum elevation of about 580 with an average elevation of about 572 feet above mean sea level.

Again, critics have assumed reduced speeds on the upper St. Lawrence River. An examination of Canadian and American regulations dealing with the Thousand Island section of the river shows that there is no speed limit in the 67 miles of the so-called "restricted" channel. This is attested also by operating men of steamship lines

using this route. Mr. H. McClymont, operating manager of the Canada Steamship Lines, Ltd., which operates the largest fleet of vessels over the St. Lawrence canals, informs the Survey as follows:¹⁵

In regard to the speed to which our boats may be restricted in passing through the Thousand Island section of the St. Lawrence River, I have to say that there are no restrictions in this part of the river either on the United States or Canadian side. Our vessels use the American channel exclusively through most of the Thousand Island section and the only spot where there is any attempt of restriction is at Point Vivian where there is a "slow" sign, having reference to a zone limit. This signboard, however, is understood by all our pilots to have reference only to the speed of yachts in the vicinity of Point Vivian so that they will not approach the dock or the zone where small yachts are moored at excessive speed. As you probably know, there are speedboats of 30 or 40 miles an hour in these waters which can stop very quickly and the notice is a warning to this kind of craft not to endanger property while rushing through the zone at enormous speed.

As far as our own boats are concerned, I believe our passenger steamer which is a paddle-wheel ship, voluntarily slows down near Brockville, when the large yacht is at the private dock, but this is a matter of courtesy and not a regulation. There are also, of course, the regulations which require slowing down in passing a dredge at work, but outside of this, the river is unrestricted and unregulated in regard to the speed of ships in both channels between Cape Vincent or Kingston to Ogdensburg or Prescott.

On the basis of the conditions prevailing in the Great Lakes and connecting channels, the Welland Canal and the St. Lawrence, it is now possible to recompute the probable time of passage for an average ship whose normal operating speed is 12 miles an hour. This is done in table 14, which gives the probable time of passage in different sections of the route from Duluth to Montreal. In the open waters of the Lakes, as well as in channels where there are no speed limits, an average of 12 miles an hour has been assumed. Allowance was made for the necessary slowing up of speed at the approaches to canals and locks. The time of passage through the Welland Ship Canal is assumed to be 9 hours, which is considered very conservative in the light of the evidence presented in the foregoing pages. Travel through the upper reaches of the St. Lawrence River is computed on the basis of 10 miles per hour in open channels with an average of one-half hour for single lockage, and 1 full hour for lockages in flight, as at the Beauharnois development.

¹⁵ Letter from H. McClymont, operating manager, Canada Steamship Lines, Ltd., to N. E. Daniellian, Director, St. Lawrence Survey, November 9, 1940.

TABLE 14

Estimated time required to navigate proposed St. Lawrence Seaway, Duluth to Montreal

Location	Hours	Location	Hours
Lake Superior: Duluth to St. Marys River.....	32.0	St. Lawrence River:	
St. Marys River:		Lake Ontario to Chimney Point.....	5.6
Head of River to St. Marys Falls Canal.....	1.2	Chimney Point to Point Three Point.....	2.3
St. Marys Falls Canal.....	1.0	Point Three Point Canal (Crysler	
St. Marys Falls to Point Detour.....	4.1	Island).....	1.0
Lake Huron:		Point Three Point Canal to Grass	
Point Detour to St. Clair River.....	18.6	River Canal.....	.9
St. Clair River.....	3.3	Grass River Canal (Barnhart Island).....	2.0
Lake St. Clair.....	1.5	Grass River Canal to Colquhoun	
Detroit River.....	2.6	Island.....	.8
Lake Erie to Welland Ship Canal.....	18.2	Lake St. Francis.....	2.3
Welland Ship Canal.....	9.0	Soulanges-Beauharnois Canal.....	4.5
Lake Ontario: Welland Ship Canal to St.		Lake St. Louis.....	1.3
Lawrence River.....	13.3	Lachine Canal, Lachine to Montreal.....	3.3
Subtotal, Duluth to St. Lawrence		Subtotal, Lake Ontario to Montreal.....	24.0
River.....	104.8	Total, Duluth to Montreal.....	128.8

These assumptions, of course, are based upon the further assumption that weather conditions will permit the maintenance of these normal speeds. Upon these bases the total time of passage over the 1,348 miles from Duluth to Montreal is estimated at 128.8 hours, or almost 5½ days. This compares with the normal time of passage of 112.3 hours if a speed of 12 miles per hour could be maintained all the way over the same distance of 1,348 miles. In other words, the restricted channels, canals, and locks would mean a delay of 16.5 hours one way, or 33 hours for each round trip between Montreal and Duluth. Another way of stating it is that over the whole run, the average speed would be reduced to 10.4 miles per hour for a ship with a normal speed of 12 miles per hour. This must be compared with the claim by some critics of the project that the effective speed of ships over the whole course of the St. Lawrence route would be reduced to three-quarters normal speed. The actual over-all reduction of speed would be only 14 percent; or to put it otherwise, the time consumed in a round trip between Montreal and Duluth would be extended by a day and a half as a result of necessary lockages and canal travel, instead of 3 days as claimed.

This delay can be compensated for by speeding up travel in the open stretches of water above 12 miles per hour. Such a feat is not beyond the bounds of possibility. The new ships designed by the Maritime Commission have speeds of 16 to 20 miles per hour, and the average speed of ships of foreign registry is also on the increase because of the higher speeds of newly constructed boats.

Section 5

HAZARDS ON THE ST. LAWRENCE ROUTE

It is also claimed that the St. Lawrence route is tortuous, often fog-bound, and therefore offers dangerous navigation. The conditions of navigation from the Atlantic to Montreal need not be discussed here, since it is sufficiently safe to make Montreal the second largest port on the Atlantic-Gulf seaboard in passenger-ship sailings. Similarly, conditions on the Great Lakes and in the connecting channels need no further justification, since they are utilized widely and frequently by large lake carriers which transport one-fourth of all the foreign and domestic water-borne commerce of the United States. The stretch between Lake Ontario and Montreal is the section of the waterway which requires special consideration.

The recommendations of the Joint Board of Engineers in 1926 included specifications for improving the channels and canals over this stretch of the river in order to provide safe passage for deep-draft ships. The channels would have a minimum width of 450 feet; canal sections would have a bottom width of 200 feet. Open channels are to be widened where necessary on account of cross currents and at bends, and they are to be widened and deepened in order to afford suitable current velocity. The minimum radius of curvature of the channel is to be 5,000 feet. The locks are to conform in dimensions with those in the new Welland Ship Canal, with chambers of 859 feet in length between inner quoin posts, and 766 feet between breast wall and fender. The clear width of the locks would be 80 feet, and the depth over the sills 30 feet.¹⁶

These channel dimensions may be compared with the channel up the Hudson River, 145 miles to Albany, N. Y. This, a much frequented channel of navigation, has a depth of 27 feet and width of 300 feet, widening to 400 feet in rock cuts.¹⁷

Then again it is asserted that the St. Lawrence route would be fog-bound during much of the open navigation season, thereby creating dangerous hazards. This claim has already been exploded.¹⁸ Records of fog conditions made available by the Assistant Deputy Minister of the Department of Railways and Canals, Canada, and introduced at the hearings before the subcommittee of the Senate Committee on Foreign Affairs in 1934, showed that fog conditions at selected points in the Great Lakes and St. Lawrence River during the open navigation season were, in fact, much more favorable than

¹⁶ *St. Lawrence Waterway Project*, Report of Joint Board of Engineers with appendices. Ottawa, November 16, 1926, p. 26.

¹⁷ Report of the Chief of Engineers, United States Army, 1939, p. 250.

¹⁸ Hearings before the subcommittee of the Senate Committee on Foreign Affairs on S. Res. 278, 72d Cong., 2d Sess., p. 705.

those at New York. According to these records, the following conditions over a period of years prevailed in the upper St. Lawrence River.

Montreal, 4 days, or 100 hours per year.

Nine Mile Point (opposite Kingston), 9 days, or 212 hours per year.

Point Peter (south of Belleville), 10.8 days, or 258 hours per year.

Toronto, 18.3 days, or 440 hours per year.

Detroit River, 13 days, or 311 hours per year.

Detour (St. Mary's River), 13.5 days, or 324 hours per year.

Point Iroquois (outlet of Lake Superior), 17 days, or 400 hours per year.

Compared with these, New York Harbor had 44 days, or 1,060 hours of foggy weather.

The best indication of the hazards to navigation in the St. Lawrence River is in the record of accidents over a number of years. In table 15 the record of accidents of canal boats traveling between Lake Ontario and Montreal is summarized. There the number of accidents with and without damage, the weather condition under which these accidents occurred, the total value of damage, and the nature of accidents are shown for the period 1935 to 1939, inclusive.

During those 5 years there was a total of 116 accidents reported by the Dominion Bureau of Statistics. Of these, 65 resulted in damages, 34 involved no damages at all, and in 17 cases the amount of damage was unknown. The weather conditions were as follows: In 76 instances, clear; in 11 instances, foggy; in 6 instances, windy; and in 19 instances, other weather disturbances existed, such as haze, storm, rain, etc. In 4 cases the condition of the weather was not stated. The most frequent accident was stranding of vessels. There were 78 such cases. Collisions also were important, accounting for 32 cases. Total reported damage in these 5 years from these accidents amounted to \$418,929.

TABLE 15

Accidents involving merchant vessels on the St. Lawrence River between Montreal and Lake Ontario, seasons of navigation, 1935-39

Year	Number of accidents				Weather conditions					Total damage	Nature of accident		
	With damage	Without damage	Unknown	Total	Clear	Foggy	Windy	Other	Unknown		Stranded	Collision	Other
1935.....	0	8	4	12	7	3	1	2	2	\$68,950	5	5	2
1936.....	23	7	4	34	25	3	1	5	1	169,228	23	9	2
1937.....	12	6	4	22	14	4	2	1	1	40,585	14	7	1
1938.....	12	10	6	28	19	3	1	5	1	70,386	23	4	1
1939.....	0	8	3	20	11	1	2	6	1	69,780	13	7	1
Total.....	65	34	17	116	76	11	6	19	4	418,929	78	32	6

SOURCE: Canadian Department of Transport, *Wreck Register*.

NOTE.—None of the casualties occurring during the above 5-year period caused loss of life. In 1937 1 life was lost as a result of an explosion aboard a vessel.

This record should be contrasted with the number of vessel passages that took place in way and through traffic over the St. Lawrence route, and the total tonnage of freight moved in each of those years, as shown below:

Year	Total vessels	Total freight moved
1935	10,326	<i>Net tons</i> 6,873,655
1936	10,460	8,288,524
1937	10,204	9,195,439
1938	9,889	9,236,318
1939	9,359	8,340,165

SOURCE: Canada, Dominion Bureau of Statistics, *Canal Statistics*.

On the face of this evidence, it must be admitted that over the distance of 183 miles from the foot of Lake Ontario to Montreal, the actual experience would not indicate, in the light of the number of vessel passages and total tonnage, a very great hazard to navigation. Indeed, contrasted with the experience over the 50-mile stretch in the Panama Canal during the same 5 years, where there are only 3 sets of locks, one of which has 3 chambers, as compared with the 22 locks on the present St. Lawrence route, the experience on the present St. Lawrence canals is much more favorable. Table 16 shows the number and type of accidents to shipping on the Panama Canal, 1935-39 inclusive. The total number of accidents during those 5 years was 156; most of these accidents involved contact with lock walls and docks.

TABLE 16

Number and type of accidents to shipping on the Panama Canal, 1935-39

Cause of accident	1935	1936	1937	1938	1939
Ship struck lock walls	3	9	14	5	7
Ship struck docks	5	8	7	3	4
Ship struck canal bank	4		4	4	2
Ship struck and damaged buoys		2	2		
Damaged by tugs which were assisting vessel		1	3	4	6
Struck by another vessel while secured to dock			2		
Broke chocks while in locks		2	2		
Struck lock fender chain			1		
Sinking after collision		1			
Sinking after springing a leak			1		
Collision				1	2
Damaged by fire while fueling			1		
Damaged by broken oil hose while fueling			1		
Line fouled propeller	4	3			
Damage to submerged cable	2	1			
Hit submerged object	1	2			
Grounded	2	1		1	4
Struck wall adjacent to drydock gate				1	
Tug damaged by ship				1	
Ship damaged by dredge				1	
Explosion and fire				1	
Emergency anchoring				1	
Other causes	7	8	11		3
Total	28	28	50	23	27

SOURCE: Annual Reports of the Governor of the Panama Canal, 1937 and 1939, p. 43.

Of course the character of shipping on the present St. Lawrence canals and in the Panama is quite different. On the other hand, the shipping in each instance is peculiarly adapted to the specifications of the route with regard to depth and width of channels and canals. Allowing for this difference it would still seem that the record of the 183 miles on the upper St. Lawrence River, as compared with the 50 miles at Panama, is quite favorable, particularly in view of the fact that the number of vessel transits in the St. Lawrence was almost twice as many as at Panama,¹⁹ and the number of locks 22 as against 3 at Panama. The number of transits in the Panama Canal for the 5-year period were as follows: 1935, 5,180; 1936, 5,382; 1937, 5,387; 1938, 5,525; 1939, 5,903—about half of the transits on the St. Lawrence.

Section 6

REQUIRED DRAFT OF VESSELS

Much controversy has surrounded the question of the proper depth for the St. Lawrence Seaway, which would permit ocean shipping to utilize it. The Joint Board of Engineers in 1926 recommended a depth of 25 feet for all channels, with lock sills down to 30 feet for future deepening of the canals. In 1932 the Canadian and United States Governments adopted 27 feet as the practical initial depth of channels. It has even been recommended that the most useful depth would be 35 feet.²⁰ The most frequent discussion on the subject assumes an initial depth of 27 feet, with an ultimate depth of 30 feet. This would make the dimensions of the St. Lawrence route comparable to the ultimate scale of the Welland Ship Canal as now planned.

The principal considerations in the adoption of the depth of channels are, on the one hand, the cost of the project, and on the other hand, the requirements of ocean shipping. In this section an attempt will be made to analyze world shipping in relation to channel depths.

First, it is necessary to settle the question of required clearance between keel, and channel and canal bottoms. In discussing this matter it is well to keep in mind that salt-water draft varies slightly from fresh-water draft. Although this would differ for ships of different sizes, for convenience it is sufficient to assume a variation of 6 inches between the two; i. e., a ship would draw 6 inches more in fresh water than in salt water. Allowance must be made for this feature in discussing the required draft of channel and vessels.

Some critics have been of the opinion that vessels require a minimum clearance of 2½ feet between keel of ship and channel floor.²¹

¹⁹ Annual Report of the Governor of the Panama Canal, 1939, p. 9.

²⁰ C. P. Wright, *The St. Lawrence Waterway, a Canadian Appraisal*, Toronto, Ontario, 1935.

²¹ Moulton et al., *Op. Cit.*, p. 37.

On the other hand, the Joint Board of Engineers, in its report of 1926, assumed that a channel 27 feet deep would be suitable for safe and convenient navigation by vessels loaded to 25 feet in salt water, which would give an actual clearance of $1\frac{1}{2}$ feet in fresh water.

There has developed considerable confusion with regard to this question of clearance because insufficient consideration is given to the differences between canals and channels, and to the variety of conditions encountered in different sections of a channel. Upon examination of the problem it will be found that, due to changing character of bottom and of current, wind, and ship speed, the required clearance at different parts of the route will vary. Through canals, where speed is reduced and the water is calm and practically stationary, a much smaller clearance is needed than in open channels. In the latter, too, clearance requirements must be adapted to the conditions of current and bottom. Over rocky bottoms and around bends, a greater clearance would be needed than over a straightaway with soft bottom. To put it otherwise, it will be necessary to dredge some spots deeper than others. This is accepted practice and generally applied in Great Lakes channels.

When reference is made to a 27-foot project, therefore, it must be understood to mean that over the longer course of the route, and under the most prevalent conditions, 27 feet would be the normal depth. The rockier and more dangerous spots *would* be deeper; the less dangerous and canalized sections *could* be slightly less so, if desired.

This problem was concisely explained by General Deakyne, Assistant Chief of Engineers, United States Army, before the House Committee on Rivers and Harbors in 1928.²² Speaking of required depth of Great Lakes channels, he said:

In general we have attacked the problem with a view of figuring out what it would cost to provide navigation for vessels drawing a certain draft. Instead of treating it as a channel 24 feet deep we treat it as a channel to accommodate a vessel drawing 24 feet, and that means in soft material you get 1 foot of depth under the keel of the vessel, and hard material 2 feet. In some places, where there is more wave action than in others, we have gone to as much as 3 feet under the keel of the vessel, so we have figured out these estimates for vessels drawing 22 feet, 23 feet, and 24 feet. But that means that these depths vary from 23 to 25 feet for a 22-foot channel, and from 24 to 26 feet for a 23-foot channel, and from 25 to 27 feet for a 24-foot channel. They are treated as channels for drafts of 22, 23, and 24 feet.

In this survey, a normal depth of 27 feet in canals is assumed as the controlling depth, with full expectation that open channels, particu-

²² Hearings before the Committee on Rivers and Harbors, House of Representatives, 70th Cong., 1st Sess., on the subject of the improvement of the Great Lakes connecting channels, 1928.

larly rocky and dangerous points on the route, would have additional safeguards. Under these conditions, what are the required clearances for vessels on the St. Lawrence route?

This survey made inquiry of the National Harbors Board in Canada with regard to the required clearance of ships leaving Montreal. According to regulations as of October 1940, vessels of 10,000 gross tons and under leaving Montreal to pass down the St. Lawrence to the Atlantic are required to have a minimum clearance of 2 feet 6 inches. Vessels of over 10,000 gross tons must have 3 feet of clearance. On the other hand, vessels entering the Lachine Canal are restricted to a maximum draft of 14 feet. This does not permit any substantial clearance between keel and canal bottoms for the simple reason that over most of the canal stretches between Montreal and Lake Ontario, the minimum navigable depth is 14 to 15 feet. In some places it is as much as 16 feet.

The Department of Transport, Canada, informed the Survey that the required clearance when entering a lock is 3 inches, and in the canals, 1 foot.²³ Hence it appears that according to the Montreal Port Warden's requirements, as well as the regulations of the Canadian Department of Transport, the clearance considered safe for up-bound canal vessels is less than for down-bound ocean vessels.

This implied difference between clearance required in free channels and that required in canals is easily understandable. A boat traveling at reduced speed through the calm waters of a canal with imperceptible bends, would not be subject to a variation in its "squat" because of speed, winds, currents, and eddies; hence it is practicable to require a smaller clearance in canals and locks than in open channels. If we grant this difference, then 27-foot canals could accommodate boats at actual salt water draft of at least 25½ feet and actual fresh water draft of 26 feet. This would allow 1 foot clearance in canals, which is considered sufficient by the Canadian authorities today.

The analysis of shipping, therefore, may be based upon the assumption that ships with salt water loaded draft of 2 feet (fresh water, 1½ feet) less than the depth of canals would be able to utilize this route safely. This allows 1½ feet clearance as compared with the present regulations of 1 foot. Hence a ship of 25 feet loaded draft in salt water could proceed up the proposed St. Lawrence canals without danger. This, it will be observed, differs from the assumption of some opponents of the seaway who maintain that a clearance of at least 2½ feet is necessary.²⁴ The difference of 1 foot in the required clearance is important because the number of ships in operation having salt water loaded drafts between 24 and 25 feet form a large percentage of total tonnage of freight ships in the world.

²³ Letter of E B Jost, General Superintendent of Canals, Canada, to N R. Daniellian, Director, St. Lawrence Survey, dated November 22, 1940.

²⁴ Moulton et al., *Op. Cit.*, p. 37.

To permit the full utilization of canals of 27-foot depth, it would be advisable to deepen open channels with soft bottoms to 27½ feet, bends to 28 feet, and rocky sections to 28½ feet. The exact variations of bottom will be determined on the basis of well established engineering experience. The estimates of cost of the Board of Engineers, United States Army, always allow for such "overdepths."

The next point to be considered is: Would a sufficient number of oceangoing vessels be able to utilize the St. Lawrence Seaway as proposed? In other words, what proportion of world shipping in number and tonnage could utilize the proposed waterway at actual loaded draft of 25½ feet? Here again, much controversy has resulted. Some opponents of the project have come to the conclusion that a 27-foot project would be practically useless since only a small percentage of the available shipping could utilize it. For instance, one critic came to the following conclusion in 1928 with regard to the proportion of ships that could utilize a 27-foot channel: Approximately 38 percent of the gross tonnage of all cargo vessels engaged in the carriage of United States foreign trade, but including only 15 percent of those having a speed of 12 knots per hour; practically none of the combination passenger-cargo ships engaged in the same service; only 13 percent of the vessels operating out of Montreal on regular schedules; about 40 percent of the grain tramps clearing Montreal; none of the tankers, and only 19 percent of the vessels found in the trades between Atlantic and Pacific coast ports.²⁵ In arriving at these conclusions only the following groups of vessels were considered: (1) The passenger-cargo ships and the purely cargo vessels that participated in the carriage of United States foreign trade in 1926; (2) the tonnage operating out of Montreal and Quebec on regular schedules; (3) the tonnage of tramp vessels carrying grain out of Montreal in 1927; and (4) the cargo vessels and tankers engaged in the United States intercoastal trade.²⁶

The figures used excluded tankers and ships engaged in the Caribbean trade, and were compiled from unpublished data supplied by the United States Shipping Board. This approach is not altogether satisfactory since owners of shipping lines assign vessels to particular routes, having in mind the limitations of the channels and harbors that are to be utilized. There is great fluidity in the assignment of vessels to different services and routes, and hence it is necessary to analyze the character of world shipping with regard to draft in the consideration of the overseas trade, and of American-owned ships in the coastwise and intercoastal trade.

At the close of 1939, according to the records of the United States Maritime Commission, the oceangoing merchant ships of the principal

²⁵ Moulton et al., *Op. Cit.*, pp. 42-49.

²⁶ *Ibid.*

maritime nations, with gross tonnage of 2,000 tons or over, numbered 9,161, having a total gross tonnage of 51,987,176. The Commission's records classify these vessels under three broad groupings: Combination passenger-cargo vessels, freight vessels, and tankers. Each of these groups is again broken down according to size, speed, loaded draft, age, and propulsion.

Turning first to a segregation of the world's fleet by service types, table 17 shows that approximately 70 percent of all the vessels and 58 percent of the total gross tonnage, included in the Commission's statistical statement, fall within the freight-vessel group; that 13 percent of the vessels, composing almost 21 percent of the total gross tonnage, are of combination passenger-cargo class; and that 17 percent of the vessels, including 21 percent of the gross tonnage, make up the tanker fleet. Together, the freight ships and the combination boats account for 83 percent of all the vessels and 79 percent of all the gross tonnage. It is these types of carriers that would be chiefly interested in the St. Lawrence improvement. It is significant to note that the vessels of the world's fleet shown in table 17 average 5,675 gross tons; freight vessels average 4,690 gross tons. Excluding the tankers, the average of the fleet is 5,372 gross tons.²⁷

TABLE 17

*Oceangoing merchant fleets of principal maritime nations, by types of vessels, as of Dec. 31, 1939*¹

Type of vessel	Number of vessels	Percent of total	Gross tons		
			Tonnage	Percent of total	Average per vessel
Combination passenger-freight.....	1,202	13.12	10,822,800	20.82	9,004
Freight.....	6,403	69.89	30,032,401	57.77	4,690
Tankers.....	1,556	16.99	11,131,975	21.41	7,154
Total.....	9,161	100.00	51,987,176	100.00	5,675

¹ Iron and steel, steam and motor vessels of 2,000 gross tons and over.

Source: United States Maritime Commission, Report No. 1,100 semiannual.

There were 1,296 vessels and 7,880,944 gross tons of oceangoing shipping in the United States merchant fleet alone (table 18). This registry accounts for 14 percent of the vessels and 15 percent of the gross tonnage recorded for the principal maritime nations of the world. As in the world fleet, freighters predominate in the United States. Freighters constitute about 62 percent of the vessels and 52 percent of the gross tonnage; tankers are second, accounting for 27 percent of the ships and almost 33 percent of the gross tonnage; and combination passenger-cargo ships third, with 11 percent of the vessels and 15 percent of the tonnage.

²⁷ For contrast, see Moulton et al., *op. cit.*, pp. 42-46.

TABLE 18

Oceangoing merchant fleet of United States compared with principal maritime nations, by types of vessels, as of Dec. 31, 1939¹

Types of vessel	All principal maritime nations		United States		Percent United States of all principal maritime nations	
	Number of vessels	Gross tons	Number of vessels	Gross tons	Number of vessels	Gross tons
Combination passenger-freight.....	1, 202	10, 822, 800	141	1, 219, 878	11. 7	11. 3
Freight.....	6, 403	30, 032, 401	802	4, 072, 701	12. 5	13. 6
Tankers.....	1, 556	11, 131, 975	353	2, 588, 365	22. 7	23. 3
Total.....	9, 161	51, 987, 176	1, 296	7, 880, 944	14. 1	15. 2

¹ Iron and steel, steam and motor vessels of 2,000 gross tons and over.

Source: United States Maritime Commission, Report No. 1100, Semiannual.

Tables 19 and 20 have been prepared with a view to determining the portion of world shipping that could use the proposed 27-foot Great Lakes-St. Lawrence Seaway, on the basis of registered maximum drafts. These tables classify world shipping according to registered drafts in salt water.

TABLE 19

Comparative statement of the merchant fleets of the world and of the United States, showing the relationship of 25-foot draft vessels by types¹

Type	Merchant fleet of principal maritime nations				Merchant fleet of the United States			
	Total		Percent 25-foot draft or less		Total		Percent 25-foot draft or less	
	Vessels	Gross tons	Vessels	Gross tons	Vessels	Gross tons	Vessels	Gross tons
Combination passenger-freight.....	1, 202	10, 822, 800	46. 85	26. 73	141	1, 219, 878	53. 90	34. 45
Freight.....	6, 403	30, 032, 401	70. 91	59. 00	802	4, 072, 701	64. 71	55. 80
Tankers.....	1, 556	11, 131, 975	21. 91	12. 28	353	2, 588, 365	13. 04	8. 09
Total.....	9, 161	51, 987, 176	59. 45	42. 30	1, 296	7, 880, 944	13. 27	36. 82

¹ Iron and steel, steam and motor vessels of 2,000 gross tons and over.

Source: United States Maritime Commission, Report No. 1100, Semiannual.

Table 19, which includes all types of the world's oceangoing ships, shows that 59 percent of the 9,161 vessels of 2,000 gross tons or more and 42 percent of the gross tonnage of 51,987,176 have drafts of 25 feet and under and could be accommodated in canals 27 feet deep. This all-inclusive group comprehends all the transoceanic superliners, fast passenger liners, and huge tankers, none of which would likely seek the St. Lawrence route, even if they could physically use its depth.

The 1,202 combination passenger-freight vessels which measure 10,882,800 gross tons are analyzed in table 20. About 47 percent of these ships with 27 percent of the gross tonnage in this class of vessels have maximum loaded drafts of 25 feet and under. This is a biased

result since this category includes such ships as the *Queen Elizabeth*, *Queen Mary*, *Normandie*, *Manhattan*, and other large passenger steamers, not at all interested in extending their services into the Great Lakes.

TABLE 20

*Oceangoing merchant fleets of principal maritime nations, segregated by draft, as of Dec. 31, 1939*¹

COMBINATION PASSENGER AND FREIGHT VESSELS

Draft	Vessels			Gross tons		
	Number	Percent of total	Cumulative percent	Tonnage	Percent of total	Cumulative percent
18 feet and under.....	78	6.49	6.49	332,942	3.08	3.08
19 feet.....	50	4.18	10.67	186,524	1.72	4.80
20 feet.....	65	5.41	16.08	239,369	2.21	7.01
21 feet.....	60	4.99	21.07	241,447	2.23	9.24
22 feet.....	54	4.49	25.56	256,686	2.37	11.61
23 feet.....	57	4.74	30.30	320,869	2.96	14.57
24 feet.....	101	8.40	38.70	640,541	5.92	20.49
25 feet.....	98	8.15	46.85	675,110	6.24	26.73
26 feet.....	130	10.82	57.67	1,037,221	9.58	36.31
27 feet.....	111	9.23	66.90	1,017,922	9.41	45.72
28 feet.....	142	11.81	78.71	1,571,109	14.52	60.24
29 feet.....	81	6.74	85.45	1,146,182	10.59	70.83
30 feet.....	54	4.49	89.94	830,944	7.68	78.51
31 feet.....	41	3.41	93.35	604,268	5.58	84.09
32 feet.....	28	2.33	95.68	483,868	4.47	88.56
33 feet.....	32	2.66	98.34	625,327	5.78	94.34
34 feet and over.....	20	1.66	100.00	612,671	5.66	100.00
Total.....	1,202	100.00	100.00	10,822,800	100.00	100.00

FREIGHT VESSELS

18 feet and under.....	336	5.25	5.25	1,055,185	3.52	3.52
19 feet.....	312	4.87	10.12	761,284	2.53	6.05
20 feet.....	468	7.31	17.43	1,235,945	4.12	10.17
21 feet.....	395	6.17	23.60	1,187,255	3.95	14.12
22 feet.....	436	6.81	30.41	1,468,948	4.89	19.01
23 feet.....	554	8.65	39.06	2,130,910	7.10	26.11
24 feet.....	933	14.57	53.63	4,241,532	14.12	40.23
25 feet.....	1,107	17.28	70.91	5,638,191	18.77	59.00
26 feet.....	681	10.64	81.55	3,834,015	12.77	71.77
27 feet.....	502	7.84	89.39	3,139,660	10.45	82.22
28 feet.....	341	5.33	94.72	2,408,029	8.02	90.24
29 feet.....	149	2.33	97.05	1,142,261	3.80	94.04
30 feet.....	112	1.75	98.80	1,034,558	3.44	97.48
31 feet.....	42	.66	99.46	376,955	1.26	98.74
32 feet.....	18	.28	99.74	188,834	.63	99.37
33 feet.....	10	.16	99.90	116,898	.39	99.76
34 feet and over.....	7	.10	100.00	71,941	.24	100.00
Total.....	6,403	100.00	100.00	30,032,401	100.00	100.00

TANKERS

18 feet and under.....	118	7.58	7.58	353,589	3.18	3.18
19 feet.....	5	.32	7.90	14,671	.13	3.31
20 feet.....	5	.32	8.22	13,342	.12	3.43
21 feet.....	16	1.03	9.25	55,338	.50	3.93
22 feet.....	15	.96	10.21	53,372	.48	4.41
23 feet.....	40	2.57	12.78	162,949	1.46	5.87
24 feet.....	60	3.86	16.64	274,153	2.46	8.33
25 feet.....	82	5.27	21.91	439,396	3.95	12.28
26 feet.....	196	12.60	34.51	1,232,190	11.07	23.35
27 feet.....	394	25.32	59.83	2,797,775	25.13	48.48
28 feet.....	347	22.30	82.13	3,879,588	25.87	74.35
29 feet.....	138	8.87	91.00	1,248,004	11.21	85.56
30 feet.....	86	5.53	96.53	886,553	7.96	93.52
31 feet.....	18	1.16	97.69	200,437	1.80	95.32
32 feet.....	12	.77	98.46	149,761	1.35	96.67
33 feet.....	3	.19	98.65	39,401	.35	97.02
34 feet and over.....	21	1.35	100.00	331,456	2.98	100.00
Total.....	1,556	100.00	100.00	11,131,975	100.00	100.00

¹ Iron and steel, steam and motor vessels of 2,000 gross tons and over.

Source: United States Maritime Commission, Report 1100 Semiannual.

The drafts of freight vessels, numbering 6,403 ships, of 30,032,401 gross tons, are shown in table 20, which reveals that approximately 71 percent of the world's freighters, representing 59 percent of the total gross tonnage in this class, have registered drafts 25 feet or less in salt water. These are the ships that carry the major portion of the dry cargoes moving over the trade routes of the world and the type of carrier to which the traffic potentialities of the territory tributary to the Great Lakes-St. Lawrence would appear to be highly attractive.

Table 20 shows that only 22 percent of the tankers, accounting for 12 percent of the gross tonnage, belonging to the principal maritime nations of the world at December 31, 1939, could safely use a 27-foot channel.

An examination of the United States merchant fleet, made up of 1,296 vessels having a gross tonnage of 7,880,944, as shown in table 21, indicates that approximately one-half of the vessels and about 37 percent of the tonnage have loaded drafts of 25 feet and under and could, therefore, navigate a 27-foot canal. In the combination passenger-freight class, totaling 141 vessels and 1,219,878 gross tons, boats having 25-foot drafts, account for 54 percent of the vessels and 34 percent of the gross tonnage. Those of the freight ships having drafts of 25 feet and under, numbered 802, with 4,072,701 gross tons and constituted 65 percent of the vessels and 56 percent of the tonnage of vessels in that class. Only a few tankers, 46 out of 353 in American registry, having 8 percent of the tonnage, have drafts 25 feet or less and are suitable for 27-foot canal navigation.

TABLE 21

Oceangoing merchant fleet of the United States, segregated by draft, as of Dec. 31, 1939¹

ALL TYPES

Draft	Vessels			Gross tons		
	Number	Percent of total	Cumulative percent	Tonnage	Percent of total	Cumulative percent
18 feet and under.....	21	1.62		64,827	0.82	
19 feet.....	26	2.02	3.64	95,596	1.21	2.03
20 feet.....	37	2.85	6.49	130,356	1.66	3.69
21 feet.....	20	1.54	8.03	65,484	.83	4.52
22 feet.....	35	2.70	10.73	123,902	1.58	6.10
23 feet.....	83	6.40	17.13	310,418	3.94	10.04
24 feet.....	247	19.06	36.19	1,216,155	15.43	25.47
25 feet.....	172	13.27	49.46	894,742	11.35	36.82
26 feet.....	124	9.57	59.03	792,690	10.06	46.88
27 feet.....	280	21.60	80.63	1,818,199	23.07	69.95
28 feet.....	89	6.87	87.50	712,257	9.04	78.99
29 feet.....	70	5.40	92.90	605,426	7.68	86.67
30 feet.....	27	2.08	94.98	255,407	3.24	89.91
31 feet.....	34	2.62	97.60	376,670	4.78	94.69
32 feet.....	16	1.16	98.76	172,874	2.19	96.88
33 feet.....	4	.31	99.07	73,278	.93	97.81
34 feet and over.....	12	.93	100.00	172,663	2.19	100.00
Total.....	1,296	100.00	100.00	7,880,944	100.00	100.00

TABLE 21—*Oceangoing merchant fleet of the United States, segregated by draft, as of Dec. 31, 1939*¹—Continued

COMBINATION PASSENGER-CARGO VESSELS

Draft	Vessels			Gross tons		
	Number	Percent of total	Cumulative percent	Tonnage	Percent of total	Cumulative percent
18 feet and under.....	9	6.39	6.39	29,950	2.46	2.46
19 feet.....	8	5.67	12.06	45,656	3.74	6.20
20 feet.....	11	7.80	19.86	53,748	4.41	10.61
21 feet.....	2	1.41	21.27	12,418	1.02	11.63
22 feet.....	6	4.26	25.53	31,225	2.56	14.19
23 feet.....	3	2.13	27.66	25,605	2.10	16.29
24 feet.....	14	9.93	37.59	76,718	6.29	22.58
25 feet.....	23	16.31	53.90	144,852	11.87	34.45
26 feet.....	19	13.48	67.38	161,414	13.23	47.68
27 feet.....	2	1.41	68.79	18,014	1.48	49.16
28 feet.....	7	4.96	73.75	91,481	7.50	56.66
29 feet.....	1	.71	74.46	17,226	1.41	58.07
30 feet.....						
31 feet.....	19	13.48	87.97	240,628	19.73	77.80
32 feet.....	8	5.67	93.61	92,988	7.62	85.42
33 feet.....	4	2.84	96.45	73,278	6.00	91.42
34 feet and over.....	5	3.55	100.00	104,677	8.58	100.00
Total.....	141	100.00	100.00	1,219,878	100.00	100.00

FREIGHT VESSELS

18 feet and under.....	11	1.37	1.37	32,688	0.80	0.80
19 feet.....	18	2.24	3.61	49,940	1.23	2.03
20 feet.....	26	3.24	6.85	76,608	1.88	3.91
21 feet.....	17	2.12	8.97	50,669	1.24	5.15
22 feet.....	28	3.49	12.46	89,796	2.22	7.37
23 feet.....	70	8.73	21.19	243,265	5.97	13.34
24 feet.....	222	27.68	48.87	1,093,177	26.84	40.18
25 feet.....	127	15.84	64.71	635,934	15.62	55.80
26 feet.....	74	9.23	73.94	437,658	10.75	66.55
27 feet.....	135	16.83	90.77	815,468	20.02	86.57
28 feet.....	35	4.36	95.13	240,263	5.90	92.47
29 feet.....	19	2.37	97.50	141,924	3.48	95.95
30 feet.....	5	.62	98.12	44,023	1.08	97.03
31 feet.....	9	1.13	99.25	72,036	1.77	98.80
32 feet.....	1	.13	99.38	7,916	.19	98.99
33 feet.....						
34 feet and over.....	5	.62	100.00	41,286	1.01	100.00
Total.....	802	100.00	100.00	4,072,701	100.00	100.00

TANKERS

18 feet and under.....	1	0.28	0.28	2,189	0.08	0.08
19 feet.....						
20 feet.....						
21 feet.....	1	.28	.56	2,397	.09	.17
22 feet.....	1	.28	.84	2,881	.12	.29
23 feet.....	10	2.84	3.68	41,548	1.61	1.90
24 feet.....	11	3.12	6.80	46,260	1.79	3.69
25 feet.....	22	6.24	13.04	113,806	4.40	8.09
26 feet.....	31	8.73	21.82	193,618	7.48	15.57
27 feet.....	143	40.51	62.33	984,717	38.04	53.61
28 feet.....	47	13.31	75.64	380,513	14.70	68.31
29 feet.....	50	14.16	89.80	446,276	17.24	85.55
30 feet.....	22	6.24	96.04	211,384	8.17	93.72
31 feet.....	6	1.70	97.74	64,006	2.47	96.19
32 feet.....	6	1.70	99.44	71,970	2.78	98.97
33 feet.....						
34 feet and over.....	2	.56	100.00	26,700	1.03	100.00
Total.....	353	100.00	100.00	2,588,365	100.00	100.00

¹ Iron and steel, steam and motor vessels of 2,000 gross tons and over.

Source: United States Maritime Commission, Report No. 1100 Semiannual.

In the light of the foregoing, it cannot be said that a major part of the world's shipping would be unable to utilize the St. Lawrence route when established, even if it is assumed that all traffic through the St. Lawrence is carried at fully loaded draft. However, there are other considerations which must be kept in mind in discussing the usefulness of a 27-foot project. Viewing the situation from a standpoint more closely approaching actual conditions on the world's trade routes, a 27-foot channel would accommodate a far greater portion of shipping than is indicated above.

A study of world shipping history will indicate that there is an interplay between ship designs and limitations of channels and harbors which the ships are intended to use. This has been the experience in Great Lakes shipping. It has also been the experience in other parts of the world. A ship line, for instance, wishing to utilize the Suez Canal to the Orient must necessarily design its ships to suit that traffic. This is true for ships that wish to go up the Yangtze River, or up the Amazon. They must, in their very construction, conform to the limitations imposed by the channels.

Ships are designed for specific routes and purposes. Admiral Land, Chairman of the Maritime Commission, states this point concisely:²⁸

When a vessel or group of vessels is designed for a specific route the available depths of channel are always the governing factor in the selection of maximum draft, i. e., it is recognized that ships intended to serve the port of Buenos Aires, Argentina, must not exceed in draft a figure of 28 feet when entering or leaving that port. All pertinent considerations are governed accordingly. Another illustration: In the approach to the port of Shanghai are certain bars which limit the draft rather rigidly to 28 feet. In this case, given ample power, it is possible to enter or leave drawing as much as 29 feet.

However, for a new ship a designer fixes his dimensions and deadweight so that 28 feet will not be exceeded when approaching or leaving Shanghai. Referring further to this same port, consultation of various sources of information, including charts of the river, indicate that ships exceeding 750 feet in length will have difficulty in turning. Accordingly, it is this limitation on length which is accepted for vessels intending to serve the port of Shanghai.

Thus it is not sufficient to analyze the character of shipping as now available. The St. Lawrence Seaway is a major project which will open up the greatest industrial and agricultural region in the world to ocean shipping. It will be expected that in the future the construction program of shipping lines, both foreign and American, which desire to establish services into the Great Lakes, will take into account the draft of channels. This is no extraordinary concession.

²⁸ Letter from Admiral E. S. Land, Chairman, United States Maritime Commission, to N. R. Danielian, Director, St. Lawrence Survey, dated October 24, 1940.

It is the general practice of the shipping lines. Indeed, special boats were constructed during the course of the past 7 years to ply between the Great Lakes and European ports over the 14-foot canals. Norwegian and Dutch shipowners have maintained regular services with these boats which are modern in design and efficient in operation.²⁹ When the 27-foot canals are established through the St. Lawrence and the Great Lakes, not only will a large proportion of existing world shipping be able to utilize it, but new ships to fit that service will certainly be constructed.

There are certain other factors that vitiate the significance of a study of registered draft of present-day shipping. Registered draft fully loaded does not always represent the actual operating draft of ships. This is true for several reasons: First, many ships can operate profitably with 5, 10, or even 15 percent less than capacity loads. An examination of the Maritime Commission's loading scales for the new cargo ships being constructed under its program indicates that a C-1 "B" type cargo ship, which has a draft of 27 feet 7½ inches fully loaded at 9,270 deadweight tons, would draw 25 feet at around 7,950 tons. A C-3 type of ship, which has a loaded draft of 28 feet 7½ inches, carrying 12,532 deadweight tons, would draw 25 feet at 10,000 deadweight tons. The C-2 type of cargo boats which draw 25 feet 10½ inches when loaded to 9,750 tons deadweight, would draw 25 feet at 9,350 deadweight tons. Although it would certainly be profitable to load a ship to full cargo in one port, freight offerings frequently do not permit such loading. As elsewhere, ships could operate profitably loaded to 80 or 90 percent of their capacity in the Great Lakes, and picking up additional cargo and supplies after passing the St. Lawrence Seaway.

A second factor which modifies the significance of registered draft is the effect of the consumption, while en route, of fuel, water, and supplies. This may first appear to be an inconsequential item, but an examination of actual trips indicates that the difference on account of these factors in the draft of a fully loaded ship between the origin of a ship in overseas ports and Montreal, just before entrance into the St. Lawrence canals, would be as much as 2 or 3 feet.

The following are examples of trips and the effect of consumption of water and stores upon the draft of these ships on selected voyages. This information was supplied by the United States Maritime Commission.³⁰

²⁹ See illustrations opposite page 8.

³⁰ Letter from Admiral E. S. Land, Chairman, United States Maritime Commission, to N. R. Danielian, Director, St. Lawrence Survey, July 19, 1940.

1. S. S. *Delbrasil*, Rio de Janeiro to Montreal:

Miles traveled (approximately).....	7,400 n. m.
Number of passengers carried.....	67
Number in crew.....	76
Speed.....	16.5 knots
Time at sea.....	18 days 16 hours

	Tons	Draft, fresh water	Draft, salt water
Full load, departure.....	14,247	26' 3½"	25' 8½"
Oil, water, stores consumed..	1,562		

Full load arrival.....	12,685	23' 10¼"	23' 3"
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2. S. S. *Santa Clara*, Buenaventura, Colombia, to Montreal:

Miles traveled (approximate).....	3,555 n. m.
Number of passengers carried.....	254
Number in crew.....	158
Speed.....	16.6 knots
Time at sea.....	8 days 22 hours

	Tons	Draft, fresh water	Draft, salt water
Full load departure.....	14,410	25' 6¼"	25' 0"
Oil, water, stores consumed..	1,381		

Full load arrival.....	13,029	23' 5½"	22' 11"
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3. The sample vessel (S. S. *Conness Peak*) referred to in Senate Document 116, 73d Congress, 2d session, "Great Lakes-St. Lawrence Seaway and Power Project," Liverpool to Montreal:

Miles traveled (approximate).....	3,200 n. m.
Number of passengers carried.....	none
Number in crew.....	42
Speed.....	10 knots
Time at sea.....	13 days 8 hours

	Tons	Draft, fresh water	Draft, salt water
Full load departure.....	11,575	25' 4½"	24' 9"
Oil, water, stores consumed..	717		

Full load arrival.....	10,858	23' 11¼"	23' 4¼"
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From these data it appears that for such typical voyages the consumption of fuel, water, and stores will more than compensate for the deeper drafts in fresh water upon arrival at Montreal. This will probably hold true for voyages from any major port except those in the northeastern seaboard of the United States.³¹

³¹ Admiral Land, Chairman of the United States Maritime Commission, writes in the aforementioned letter: "Seagoing vessels are ordinarily trimmed down by the stern in order to provide greater submergence for the propeller and to give better steering qualities." As the draft values given above are mean drafts, it would be necessary in the case of vessels of such size as these to carefully watch their condition of trim and perhaps take on some water ballast forward in order to limit the draft aft to a safe value for passage through a 27-foot channel."

Thus on these three trips the difference would have amounted to almost 2½ feet in the case of the trip of the S. S. *Delbrasil* from Rio de Janeiro to Montreal, 2 feet 1 inch in the case of the S. S. *Santa Clara* from Buenaventura, Colombia, to Montreal, and 1 foot 5 inches in the case of the S. S. *Conness Peak* between Liverpool and Montreal.

The possibility of ships passing through the St. Lawrence Seaway at less than registered loaded draft is no mere hypothesis. An examination of actual drafts of ships passing in cargo through the Panama Canal indicates that in the majority of instances, actual loaded drafts are less than registered drafts.

A random test analysis of the actual drafts of ships passing through the Panama Canal in the month of July 1939 fully proves this point. In that month there were 325 loaded ships passing through the Panama Canal in both directions.³² Of these, only 17 passed through the Canal with actual drafts corresponding to their registered drafts. A total of 234 ships, almost two-thirds of the total number of ships passing through the Canal with cargo, had actual drafts less than their registered drafts. Only 74 out of 325 drew actual drafts greater than their registered drafts.

An examination of table 22, which analyzes the drafts of vessels passing through the Panama Canal in relation to their registered draft, shows that 100 ships passing from the Atlantic to the Pacific, and 41 ships passing from the Pacific to the Atlantic, or a total of 141, had drafts of 2 feet or more lighter than their registered drafts. In addition 20 ships passed through the Canal with actual drafts between 1½ and 2 feet lighter than registered draft. This group of 161 out of 325 loaded ships traveled through the Panama Canal with actual drafts of 1½ feet or more lighter than the registered draft.

The point is well sustained that because of consumption of water and supplies, or because of less than fully loaded cargo, ships do travel long distances lighter than their registered drafts.

TABLE 22

Comparison of actual loaded drafts with registered drafts of vessels passing in cargo through the Panama Canal, July 1939

Atlantic to Pacific				Pacific to Atlantic			
Actual draft less than fully loaded draft		Actual draft more than fully loaded draft		Actual draft less than fully loaded draft		Actual draft more than fully loaded draft	
Inches less	Number of vessels	Inches more	Number of vessels	Inches less	Number of vessels	Inches more	Number of vessels
5 and under.....	8	5 and under.....	6	5 and under.....	16	5 and under.....	19
6 to 11.....	10	6 to 11.....	11	6 to 11.....	24	6 to 11.....	18
12 to 17.....	5	12 to 17.....	3	12 to 17.....	10	12 to 17.....	8
18 to 23.....	13	18 to 23.....	1	18 to 23.....	7	18 to 23.....	5
24 and over.....	100	24 and over.....	2	24 and over.....	41	24 and over.....	1
Total.....	136		23		98		51

NOTE.—In addition to the above, 7 vessels passing from the Atlantic to the Pacific and 10 vessels passing from the Pacific to the Atlantic showed drafts the same as their fully loaded drafts.

SOURCE: Office of The Panama Canal and the United States Maritime Commission.

³² This figure eliminated ships traveling in ballast.

A third factor that contributes to this condition is found in the different stowage factors applicable to different kinds of commodities. Commodities with lighter density will fill a ship to capacity, without bringing the vessel down to registered draft.³³ This will be true, for instance, in the case of cotton as against grains, or in the case of automobiles which occupy large spaces, as against iron and steel.

From the foregoing considerations the conclusion is inescapable that there is today sufficient shipping with registered draft fully loaded to utilize the St. Lawrence, and there certainly is sufficient shipping both under American and foreign registry to utilize it in overseas trade, as well as on long coastwise journeys, where consumption of fuels and water and stores would permit ships even of 27 feet registered draft to use the 27-foot canals. Where cargoes fractionally less than full load would still be considered sufficiently profitable to justify going into the Great Lakes, certainly ships with registered drafts higher than 27 feet would be able to travel over the canals.

The preceding discussion must not be construed as an argument that the St. Lawrence Seaway does not present any inherent peculiarities as compared with ocean navigation. It will present a seafaring captain new problems of navigation that he will have to master. Certainly pilot service will be required in the upper St. Lawrence, as it is required in the lower stretch from Father Point to Montreal. In restricted channels the engineering plans call for construction of special anchorage for use during fog. And both hull insurance and cargo insurance will probably be fractionally higher over the St. Lawrence route as compared with North Atlantic ports. But after all these factors are considered, the problems presented by navigation through the St. Lawrence are commercial and not engineering or climatic. There are no insurmountable natural difficulties in this route. Given sufficient economic incentive, ships can and will ply their way from the Atlantic to the Great Lakes. The issue, therefore, resolves itself to this: Will there be sufficient cargo at profitable rates to lure ocean shipping to this new route? This question is considered exhaustively in Part III of the Survey reports.

In this report the principal emphasis has been placed upon the sizes and types of the world's merchant ships in relation to the dimensions of the St. Lawrence locks and canals. In view of the possibilities and advantages of a shipbuilding industry on the shores of the Great Lakes, the subject of naval craft sizes in relation to Seaway dimensions is of immediate interest.

Authoritative data bearing on battleships, aircraft carriers, cruisers, destroyers, and submarines of the United States Navy have been examined.³⁴ It was found that the depths and lock dimensions initially

³³ For comparison of density and stowage factors in different classes of commodities, see United States Tariff Commission, *Commodity Packaging Data*, December 1937.

³⁴ Thursfield, Rear Admiral H. G., edited by, *Brassey's Naval Annual*, 1939, William Clowes and Sons, Ltd., London, pp. 264-70 and 302-7

planned for the Seaway are not of sufficient capacity to accommodate battleships or aircraft carriers. The battleship *New York*, completed in 1915, is 573 feet long, 106 feet wide, has a draft of 26 feet and displacement of 27,000 tons. The other vessels of the battleship group are larger. The smallest of the aircraft carriers is 688 feet long and 80 feet wide, the same as that planned for the locks, and thus precludes transit.

On the other hand, cruisers, destroyers, and submarines would find ample depths and widths in the locks and canals and channels of the St. Lawrence route.

In size, cruisers range upward from the so-called *Omaha* class. This class of vessels has a length of 555.5 feet on the waterline, a width of 55.3 feet, draft of 13.5 feet, and standard displacement of 7,000 tons. The larger *Phoenix*, *Wichita*, and *Brooklyn* classes, have lengths of 600 feet, widths of 61.5 feet, drafts of 19.8 feet, and displacement of 10,000 tons. Several new cruisers of the *Phoenix* class are under construction.

Turning to destroyers, the smallest ones are those constructed during the World War. These range 314 feet in length, 31 feet in width, 9.8 feet draft, and are from 1,000 to 1,200 tons displacement. The largest ones recently constructed are 381 feet long, 36.3 feet wide, with a draft of 10.5 feet and displacement of 1,850 tons.

The smallest submarine is 172 feet long, 17.5 feet wide, 13 feet, 3 inches draft, and has a surface displacement of 480 tons. The largest submarine is 371 feet long, 33.8 feet wide, 16 feet draft, and has a surface displacement of 2,730 tons.

These drafts are based on standard displacement, which does not include fuel and reserve feed water. When fully loaded, the vessels might draw as much as 2 or 2½ feet more water than the above figures. Even allowing for this, the St. Lawrence route would provide ample depth for these classes of vessels.

It can be confidently stated, then, that all types of American naval vessels can pass through the locks and canals of the St. Lawrence Seaway, except battleships and airplane carriers. In the case of battleships, both width and depth would be the limiting factors. In the case of airplane carriers, width would be the controlling element.

This restriction on the largest naval ships is not peculiar to the St. Lawrence canals. Even on the Atlantic and Pacific coasts there are but few ways and channels which accommodate such vessels comfortably. The limitations of the St. Lawrence route with respect to capital ships are no great handicap to the national shipbuilding program, since comparatively few of these ships form the backbone of our Navy, while large numbers of cruisers and destroyers constitute the protective screen of continental defense. And these ships could easily be constructed in the Great Lakes and accommodated in the proposed St. Lawrence Seaway.